APPENDIX K:

PARAMETRIC ANALYSIS: ENVIRONMENTAL IMPACTS OF CONVERSION, LONG-TERM STORAGE, MANUFACTURE AND USE, AND DISPOSAL OPTIONS FOR PROCESSING LESS THAN THE TOTAL DEPLETED UF_6 INVENTORY

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NOTATION (APPENDIX K)

The following is a list of acronyms and abbreviations, including units of measure, used in this document. Some acronyms used only in tables are defined in those tables.

ACRONYMS AND ABBREVIATIONS

General

CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
LCF	latent cancer fatality
LLNL	Lawrence Livermore National Laboratory
LLMW	low-level mixed waste
LLW	low-level radioactive waste
MEI	maximally exposed individual
NEPA	*National Environmental Policy Act*
PEIS	programmatic environmental impact statement
ROI	region of influence

Chemicals

HF	hydrogen fluoride
MgF_2	magnesium fluoride
NO_x	nitrogen oxides
UF_6	uranium hexafluoride
UO_2	uranium dioxide
U_3O_8	triuranium octaoxide (uranyl uranate)

UNITS OF MEASURE

d	day(s)
ft	foot (feet)
ha	hectare(s)
km	kilometer(s)
L	liter(s)
μg	microgram(s)
m	meter(s)
m^3	cubic meter(s)
mrem	millirem(s)
MWh	megawatt-hour(s)
pCi	picocurie(s)
rad	radiation absorbed dose(s)
rem	roentgen equivalent man
yd^3	cubic yard(s)
yr	year(s)

APPENDIX K:

PARAMETRIC ANALYSIS: ENVIRONMENTAL IMPACTS OF CONVERSION, LONG-TERM STORAGE, MANUFACTURE AND USE, AND DISPOSAL OPTIONS FOR PROCESSING LESS THAN THE TOTAL DEPLETED UF_6 INVENTORY

The U.S. Department of Energy (DOE) is proposing to develop a strategy for long-term management of the depleted uranium hexafluoride (UF_6) inventory currently stored at three DOE sites near Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. This programmatic environmental impact statement (PEIS) describes alternative strategies that could be used for the long-term management of this material and analyzes the potential environmental consequences of implementing each strategy for the period from 1999 through 2039. This appendix provides detailed information describing the parametric analysis used to assess potential environmental impacts of conversion, long-term storage, manufacture and use, and disposal options considered in the PEIS for processing less than the total depleted UF_6 inventory.

The environmental impacts presented in Chapter 5 of the PEIS are based on the assumption that all facilities would be designed to either convert, store, manufacture and use, or dispose of all of the depleted UF_6 in the DOE inventory. This approach provided a conservative estimate of the impacts that could result from each of the alternatives considered. Detailed discussions of the estimated environmental impacts from processing the entire depleted UF_6 inventory are presented for cylinder preparation, conversion, long-term storage, manufacture and use, disposal, and transportation options in Appendices E through J, respectively. The results of these evaluations are referred to as “100%” cases because they are based on the assumption that all of the depleted UF_6 would be processed (i.e., converted, stored, manufactured and used, disposed of, or transported).

In contrast to the 100% cases, the parametric analysis cases presented in this appendix considered the environmental impacts of each option category if the facilities were designed to process or accommodate only a fraction of the depleted UF_6 inventory (in the event that DOE would select a combination of alternatives to manage the entire inventory; see below). The intent of the parametric analysis was to show how the environmental impacts calculated for the 100% cases would be affected by reductions in facility size and throughput. “Throughput” is a general term that refers to the amount of material handled or processed by a facility in a year. Sections K.2-K.6 of this parametric appendix present the environmental impacts for the conversion, long-term storage, manufacture and use, disposal, and transportation options for facilities designed to process between 25% and 100% of the depleted UF_6 inventory. (The impacts of the cylinder preparation options for various throughputs are addressed in Appendix E.)

The results of the parametric analyses for the individual management components presented in Sections K.2-K.6 can be compiled to estimate the environmental impacts of combinations of alternatives; for example, use of 50% of the inventory as metal and use of 50% of the inventory as oxide. An example calculation of impacts for such a combination of alternatives is provided in Section K.7. Any combination of alternatives selected would result in management of 100% of the depleted UF_6 inventory. The results of the parametric analyses can also be used to estimate the impacts for situations in which more than one site would be used (e.g., conversion to oxide at two locations).

For assessment purposes, the parametric analysis assumed that all facilities would be designed to operate over a 20-year time period (i.e., the period required to process the DOE-generated cylinders, similar to the 100% cases presented in Appendices E through J). Thus, it was assumed that the processing of only a fraction of the DOE depleted UF_6 inventory would be accomplished by building and operating smaller facilities than those required for the 100% cases. In practice, it would be possible to process a fraction of the inventory by operating facilities designed to process 100% of the inventory over 20 years for a reduced time period, such as 10 years, or by operating the facility at a reduced level. In addition, changes in operating schedule could be used to accommodate small changes in the DOE inventory. For example, a 10% increase in the total DOE inventory could be accommodated by operating a full-scale facility for 22 years instead of 20.

For a given option, the environmental impacts resulting from the parametric analysis cases would tend to be less than or equal to those presented for the 100% cases. Thus, if the impacts were negligible for the 100% case, the impacts for the parametric cases would also be negligible. For most areas considered — such as human health and safety during normal operations, water, ecology, resource requirements, waste management, land use, and socioeconomics — the impacts would decrease as the facility size or throughput decreased. However, the reduction in impacts would not always be proportional to the reduction in throughput. For example, a facility designed to process 500 cylinders per year would generally have smaller impacts than a facility designed to process 1,000 cylinders per year, although the impacts would not necessarily be half of those of the larger facility. For accidents producing the greatest consequences, impacts would tend to be the same for the parametric analysis cases and the 100% case, primarily because these types of accidents would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput.

The following sections summarize the approach and results of the parametric analysis. Section K.1 presents a short summary of the assessment approach. The results are presented for the conversion options in Section K.2, for long-term storage options in Section K.3, for manufacture and use options in Section K.4, for disposal options in Section K.5, and for transportation options in Section K.6; parametric assessment results for the cylinder preparation options are provided in Appendix E. Section K.7 presents an example of the calculation of impacts for a specific combination alternative and the summary of impacts for several example combination alternatives.

The discussion in this appendix (Appendix K) does not include details of the assessment methodologies or definitions of the options considered in the PEIS. A detailed description of methodologies is presented in Appendix C, and definitions and descriptions of the option categories are provided in Appendices F through J. Finally, in cases where the impacts from the parametric analysis do not differ significantly from the 100% case, readers are referred to Appendices F through J for additional discussion.

K.1 PARAMETRIC ANALYSIS ASSESSMENT APPROACH

Two parametric cases were analyzed for conversion, long-term storage as oxide, manufacture and use, and disposal options: (1) facilities designed to process or accommodate 50% of the depleted UF_6 inventory; and (2) facilities designed to process or accommodate 25% of the inventory. To simplify the analysis, the parametric cases were analyzed in detail for a subset of options within each option category, as summarized in Table K.1. A subset of options was selected because the relationships among the options within each category could be determined from the detailed analyses conducted for the 100% cases. Therefore, the results for the options analyzed in detail were used to estimate the impacts for all options within each category by comparison with the 100% cases.

The basic assessment approach, areas of impact, and methodologies used to evaluate the parametric cases were the same as those used to evaluate the 100% cases. The environmental impacts for the 100% cases were evaluated using information provided in the engineering analysis report (Lawrence Livermore National Laboratory [LLNL 1997a]), including descriptions of facility layouts; resource requirements; estimates of effluents, wastes, and emissions; and descriptions of potential accident scenarios. To support the parametric assessment, similar design information was used for facilities sized to process or accommodate 25% and 50% of the depleted UF_6 inventory (LLNL 1997a).

The results of the parametric analysis are presented, where appropriate, as curves that show the environmental impacts as a function of facility throughput. The curves were constructed using the results for the 25%, 50%, and 100% cases. These curves can be used to estimate the environmental impacts for throughputs ranging between 25% and 100% of the depleted UF_6 inventory. In addition, the curves can also be used to provide rough estimates of the impacts for throughputs slightly below 25% and slightly above 100%. In cases where the impacts for the 100% case were negligible, the parametric analysis was conducted to confirm that the impacts were also negligible, and only a brief discussion is provided. (The terms used in this PEIS to describe impacts, such as “negligible,” are defined in Chapter 4, Table 4.2.)

K.2 CONVERSION OPTIONS

The parametric analysis of the conversion options considered the environmental impacts of converting 25% and 50% of the depleted UF_6 inventory to triuranium octaoxide (U_3O_8), uranium dioxide (UO_2), or uranium metal over a 20-year period. The assessment considered the environmental impacts that would occur during (1) construction of a conversion facility, (2) routine conversion facility operations, and (3) potential conversion facility accidents. The areas of impact and the methodologies used to evaluate the parametric cases were the same as those used to evaluate the 100% cases, the results of which are discussed in Appendix F. The supporting data for the 25% and 50% parametric conversion cases are provided in the engineering analysis report (LLNL 1997a).

TABLE K.1 Specific Options and Parametric Cases Analyzed in Detail

Option Category/ Options Analyzed in Detail	Parametric Cases Analyzed for Each Option	
Conversion	Conversion to U_3O_8, UO_2, and metal:	
	100% case:	Conversion of 100% of the inventory over 20 years
	50% case:	Conversion of 50% of the inventory over 20 years
	25% case:	Conversion of 25% of the inventory over 20 years
Long-term storage		
Storage as UF_6 in buildings	Storage as UF_6:	
	100% case:	Storage of 46,422 cylinders
	50% case:	Storage of 23,211 cylinders
	25% case:	Storage of 11,606 cylinders
Storage as UO_2 in buildings	Storage as UO_2:	
	100% case:	Storage of 420,000 drums
	50% case:	Storage of 210,000 drums
	25% case:	Storage of 105,000 drums
Manufacture and use		
Use as uranium oxide	Use as UO_2:	
	100% case:	Use of 100% of the inventory as oxide shielding
	50% case:	Use of 50% of the inventory as oxide shielding
	25% case:	Use of 25% of the inventory as oxide shielding
Use as uranium metal	Use as metal:	
	100% case:	Use of 100% of the inventory as metal shielding
	50% case:	Use of 50% of the inventory as metal shielding
	25% case:	Use of 25% of the inventory as metal shielding
Disposal		
Disposal as ungrouted U_3O_8 in a mine	100% case:	Disposal of 100% of the inventory over 20 years
	50% case:	Disposal of 50% of the inventory over 20 years
	25% case:	Disposal of 25% of the inventory over 20 years

In general, the impacts for the 100% cases are presented in Appendix F as ranges, resulting from differences in technologies within each option and site differences. For the purposes of the parametric analysis, one technology from each option was considered and evaluated in detail at a representative site. A single technology and a representative site were evaluated for each option to simplify the parametric analysis. This simplification was possible because all technologies were evaluated at all representative sites for the 100% base case. The specific technologies considered were defluorination with anhydrous hydrogen fluoride (HF) production for conversion to U_3O_8; dry defluorination with anhydrous HF production for conversion to UO_2; and continuous metallothermic reduction for conversion to uranium metal. The resulting relationships between the technologies and sites that were identified for the 100% case were used to infer ranges of impacts for the parametric cases examined in detail.

K.2.1 Human Health — Normal Operations

K.2.1.1 Radiological Impacts

The estimated radiological impacts — radiation doses and latent cancer fatalities (LCFs) — from the normal operation of a full-scale (100%) facility for converting depleted UF_6 to U_3O_8 are described in Appendix F, Section F.3.1.1. Similar impacts were calculated for the 50% and 25% conversion facilities for the parametric analysis. The radiological impacts estimated for the 100%, 50%, and 25% case are shown in Figures K.1 through K.6 as the radiation doses for the six receptor scenarios considered in the PEIS:

- Members of the general public
  - Annual collective dose
  - Annual dose to the maximally exposed individual (MEI)

- Noninvolved workers
  - Annual collective dose
  - Annual dose to the MEI

- Involved workers
  - Annual collective dose
  - Annual average individual dose

The ranges of impacts resulting from site and technology differences for each option are represented by dashed lines in the figures. The results for the technology selected for detailed analysis are shown in the figures as solid points, with a curve drawn between the points to indicate how the impacts vary as a function of the percent of depleted UF_6 processed. The upper and lower bounds for impacts for the 25% and 50% cases were estimated on the basis of the range

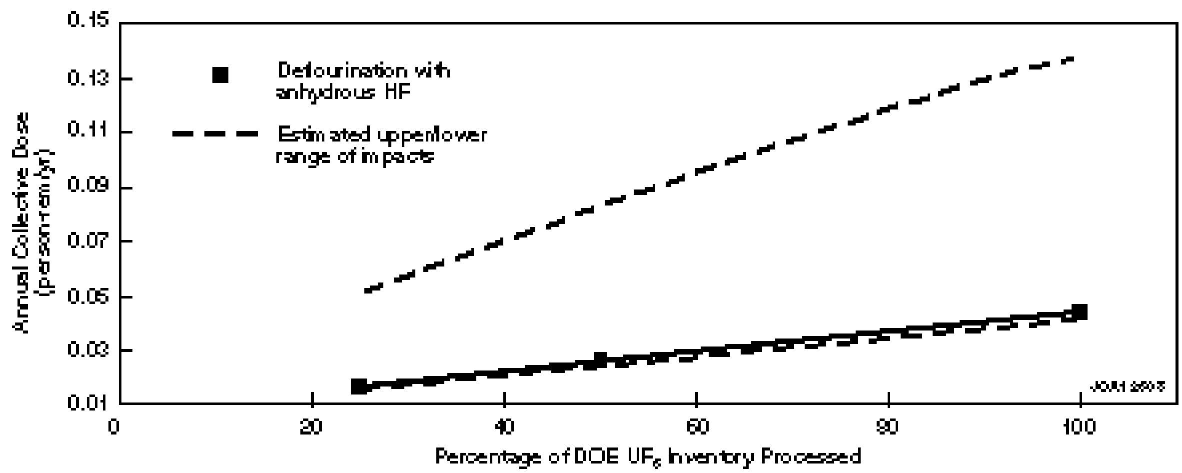

FIGURE K.1 Estimated Annual Collective Dose to Members of the Public from the Conversion of UF_6 to U_3O_8 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

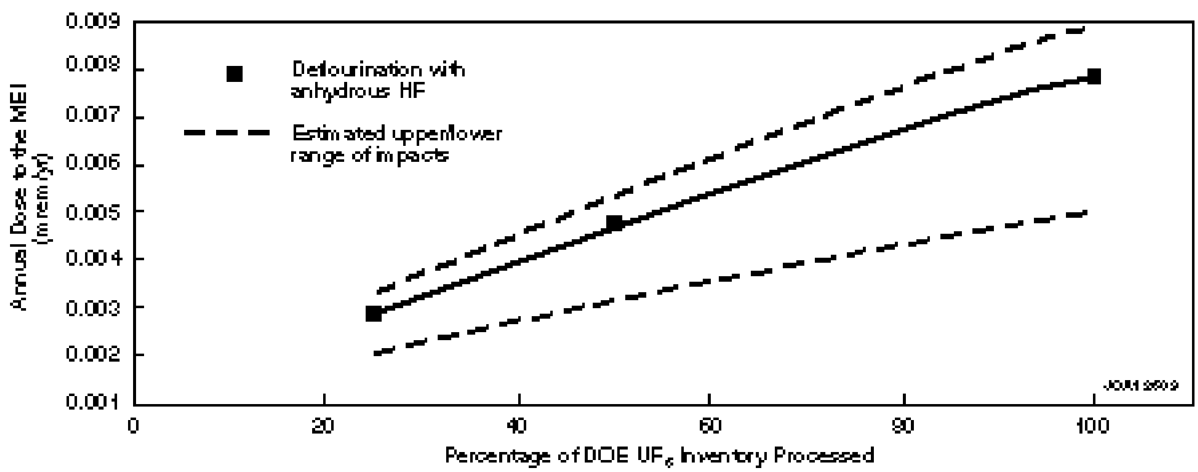

FIGURE K.2 Estimated Annual Dose to the General Public MEI from the Conversion of UF_6 to U_3O_8 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

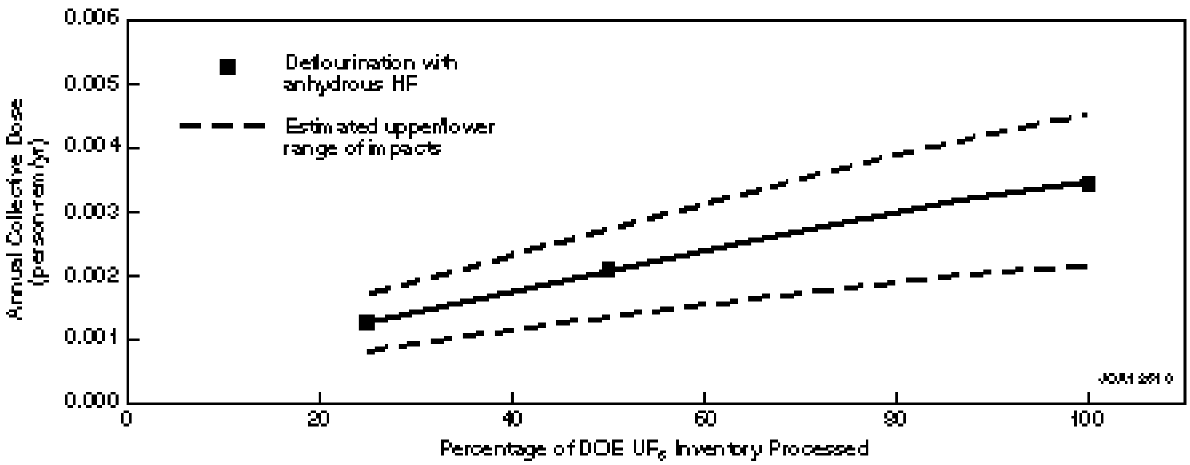

FIGURE K.3 Estimated Annual Collective Dose to Noninvolved Workers from the Conversion of UF_6 to U_3O_8 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

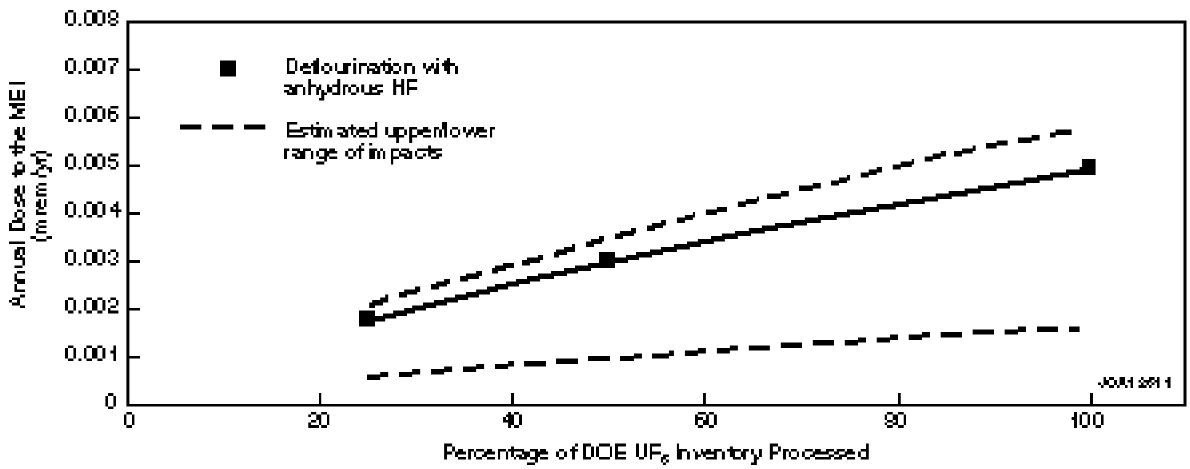

FIGURE K.4 Estimated Annual Dose to the Noninvolved Worker MEI from the Conversion of UF_6 to U_3O_8 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

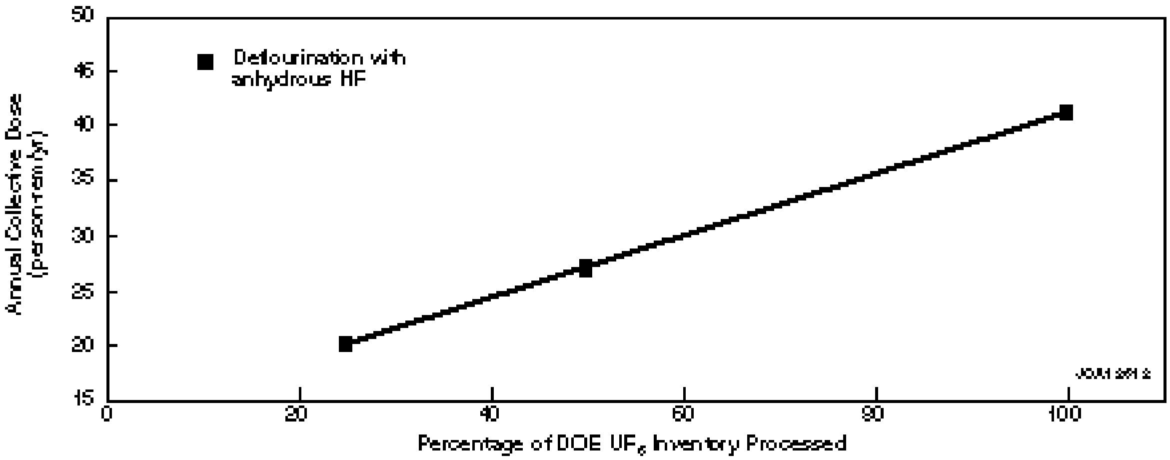

FIGURE K.5 Estimated Annual Collective Dose to Involved Workers from the Conversion of UF_6 to U_3O_8 (No range is presented because the estimated collective doses to involved workers were almost identical between conversion technologies.)

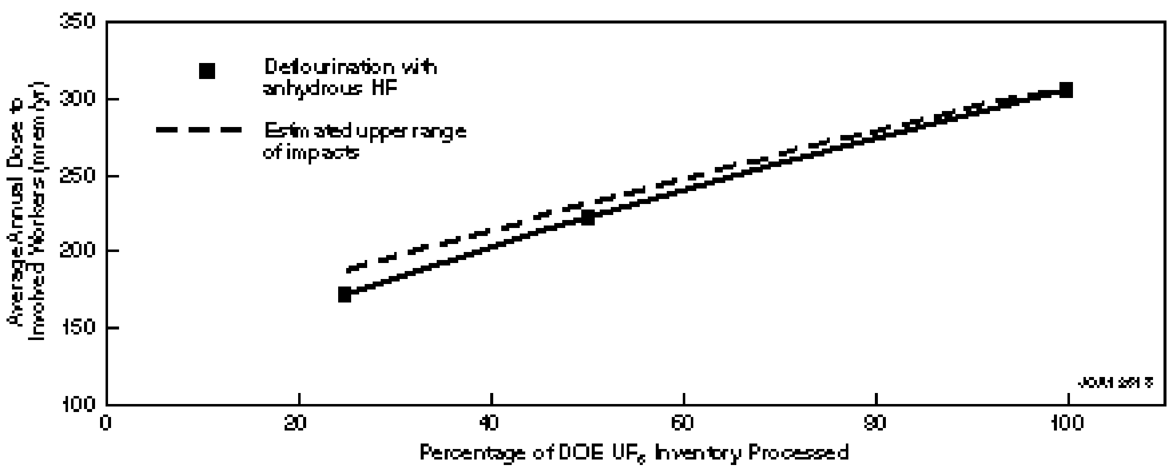

FIGURE K.6 Estimated Annual Average Individual Dose to Involved Workers from the Conversion of UF_6 to U_3O_8 (The upper and lower ranges reflect differences in conversion technologies.)

determined for the 100% case. The area enclosed by the lines in each figure indicates the range of impacts expected for throughputs between 25% and 100%, taking into account both technology and site differences.

The results of the parametric analysis for conversion to U_3O_8 (as shown in Figures K.1 through K.6) indicate that the radiological impacts would scale relatively linearly with the quantity of depleted UF_6 processed annually. The impacts of the 25% and 50% cases would be smaller than those for the 100% case, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than half of the impacts for the 100% case). The radiation doses to the general public would be greater than those to noninvolved workers because of longer exposure times and, for the collective dose, larger population size. The doses shown in the figures can be converted to the number (or risk) of LCFs by multiplying the doses (in rem or person-rem) by 0.0005 LCF/person-rem for members of the public and 0.0004 LCF/person-rem for workers. Additional discussion of the significance of the estimated doses is provided in Appendix F.

For conversion to UO_2, the estimated radiation doses for the 100%, 50%, and 25% throughput cases are presented in Figures K.7 through K.12 for each of the six receptor scenarios considered in the PEIS. The results are presented in a manner similar to the results discussed previously for conversion to U_3O_8. The general relationship between radiological impacts and throughput for conversion to UO_2 is similar to that for conversion to U_3O_8; that is, the radiological impacts would decrease with decreasing throughput. The estimated radiological impacts (doses and LCFs) from normal operation of a full-scale (100%) facility for converting depleted UF_6 to UO_2 are described in Appendix F, Section F.3.1.1.

For conversion to metal, the estimated radiation doses for the 100%, 50%, and 25% throughput cases are presented in Figures K.13 through K.18 for each of the six receptor scenarios considered in the PEIS. Similar to conversion to U_3O_8 and UO_2, the radiological impacts from conversion to metal would decrease with decreasing throughput. The estimated radiological impacts (doses and LCFs) from the normal operation of a full-scale (100%) facility for converting depleted UF_6 to uranium metal are described in Appendix F, Section F.3.1.1.

The estimated radiological impacts from operation of the cylinder treatment facility are less than the impacts from the operations of the conversion facilities. Low-level exposures would be expected for involved workers and negligible exposures for noninvolved workers and the general public. The estimated radiation doses for the 100%, 50%, and 25% throughput cases are presented in Figures K.19 through K.24 for each of the six receptor scenarios considered in the PEIS.

K.2.1.2 Chemical Impacts

The estimated impacts from chemical exposures during the normal operation of full-scale (100%) facilities for converting depleted UF_6 to U_3O_8, UO_2, and uranium metal are described in Appendix F, Section F.3.1.2. The results of the 100% case analyses indicated that noninvolved

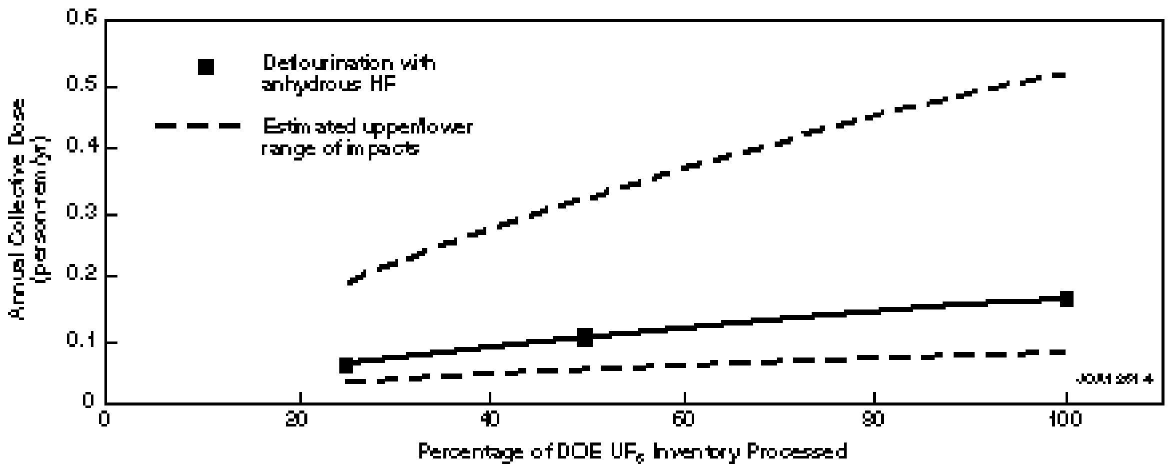

FIGURE K.7 Estimated Annual Collective Dose to Members of the Public from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

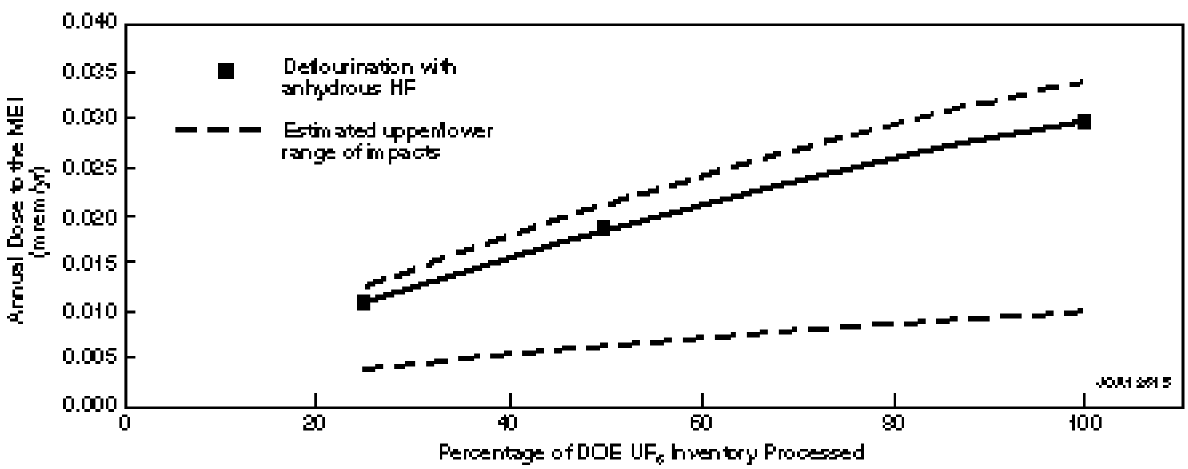

FIGURE K.8 Estimated Annual Dose to the General Public MEI from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

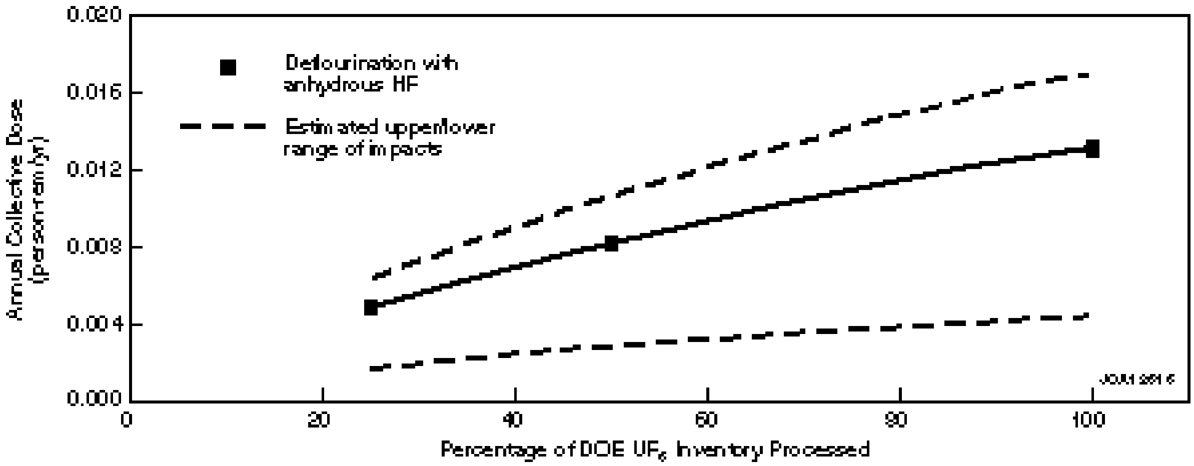

FIGURE K.9 Estimated Annual Collective Dose to Noninvolved Workers from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

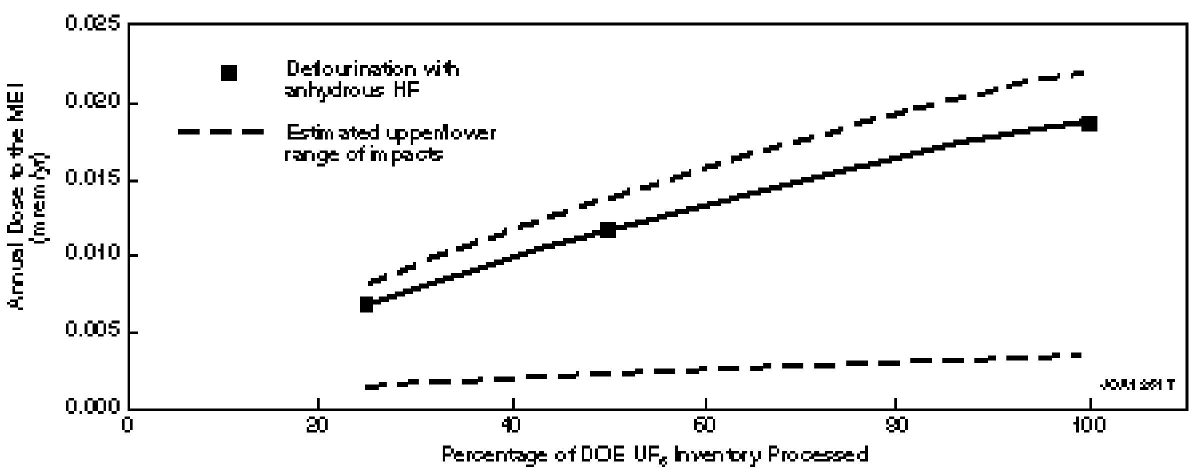

FIGURE K.10 Estimated Annual Dose to the Noninvolved Worker MEI from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

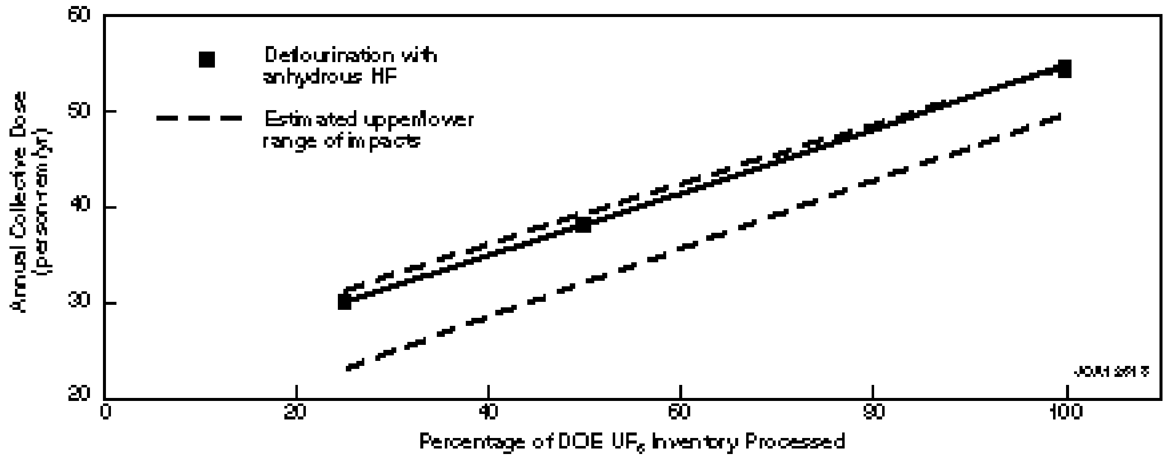

FIGURE K.11 Estimated Annual Collective Dose to Involved Workers from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in conversion technologies.)

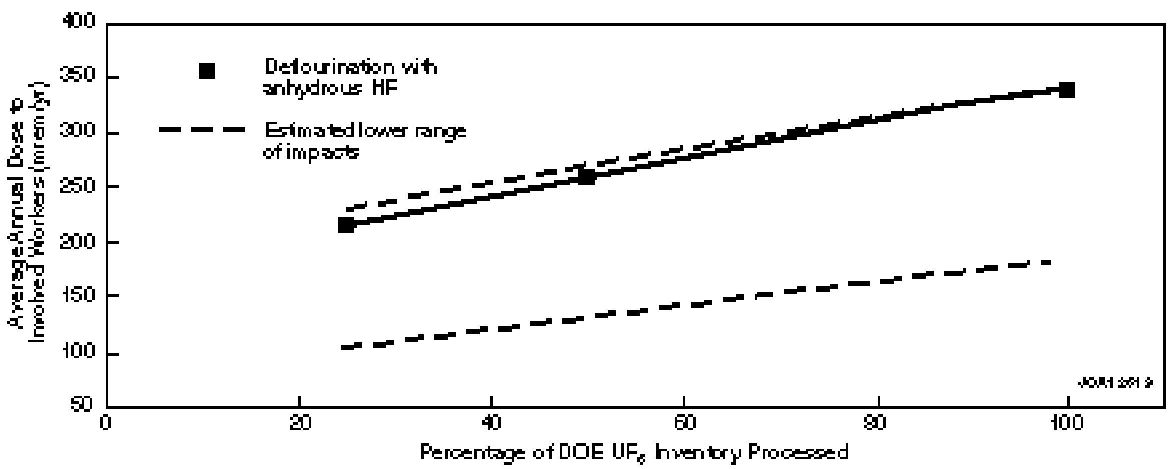

FIGURE K.12 Estimated Annual Average Individual Dose to Involved Workers from the Conversion of UF_6 to UO_2 (The upper and lower ranges reflect differences in conversion technologies.)

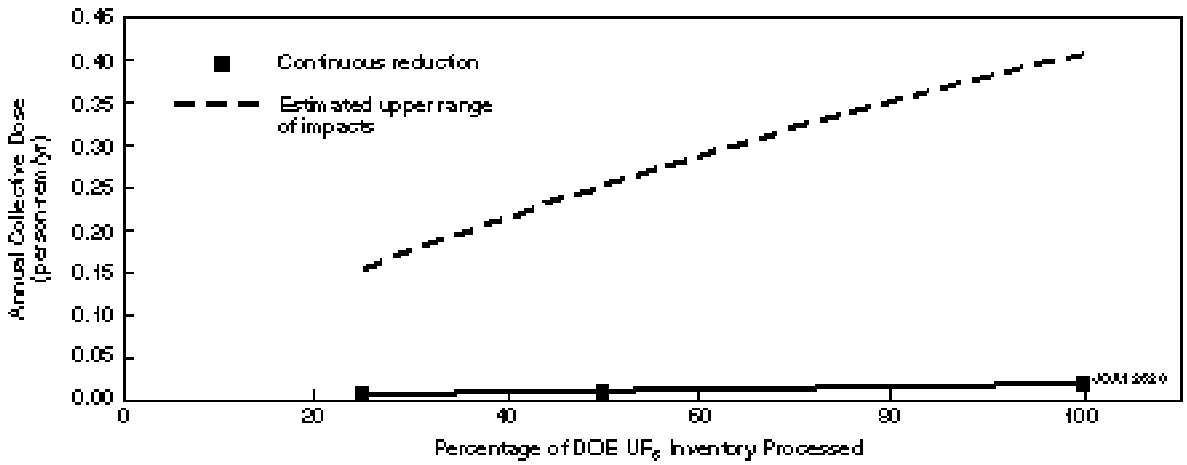

FIGURE K.13 Estimated Annual Collective Dose to Members of the Public from the Conversion of UF_6 to Uranium Metal (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

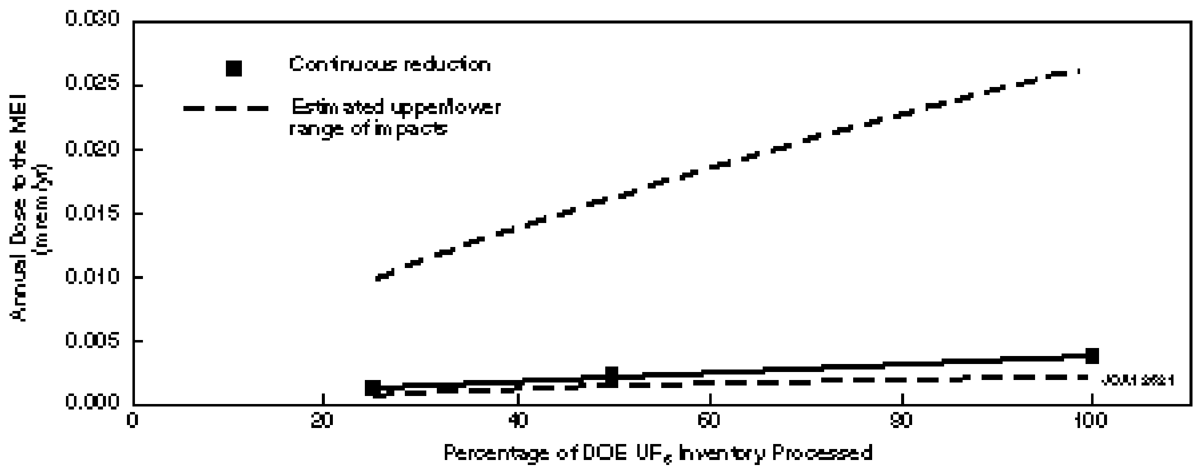

FIGURE K.14 Estimated Annual Dose to the General Public MEI from the Conversion of UF_6 to Uranium Metal (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

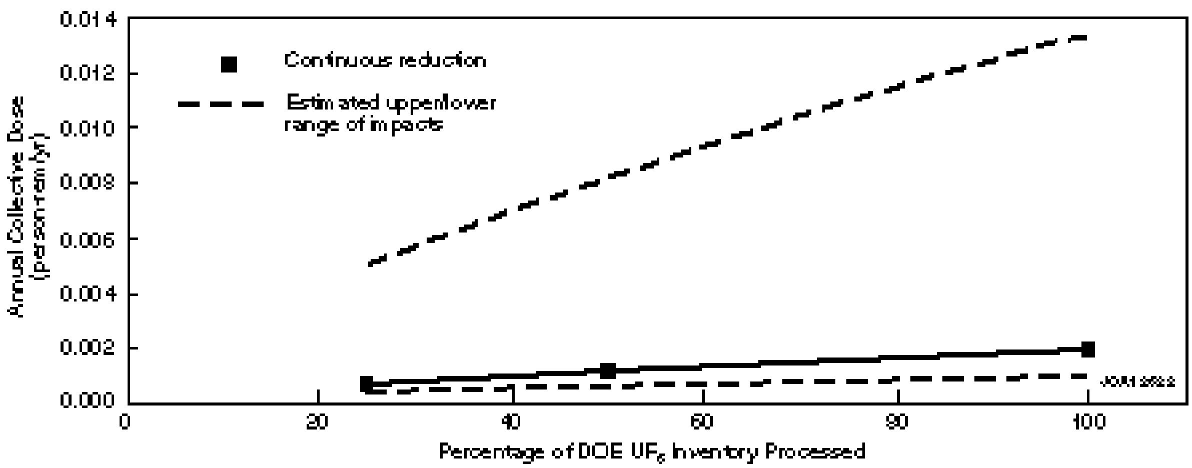

FIGURE K.15 Estimated Annual Collective Dose to Noninvolved Workers from the Conversion of UF_6 to Uranium Metal (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

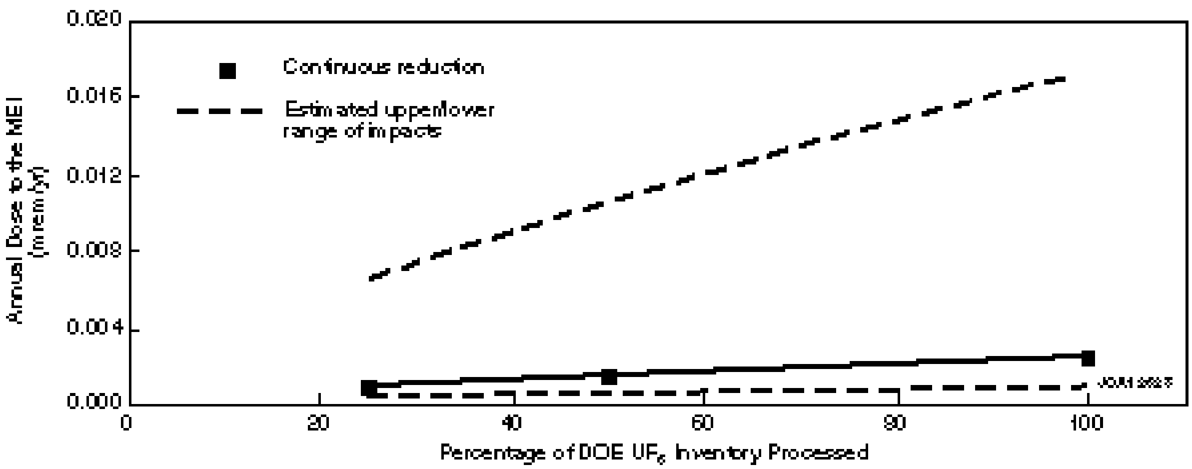

FIGURE K.16 Estimated Annual Dose to the Noninvolved Worker MEI from the Conversion of UF_6 to Uranium Metal (The upper and lower ranges reflect differences in both conversion technologies and representative site characteristics.)

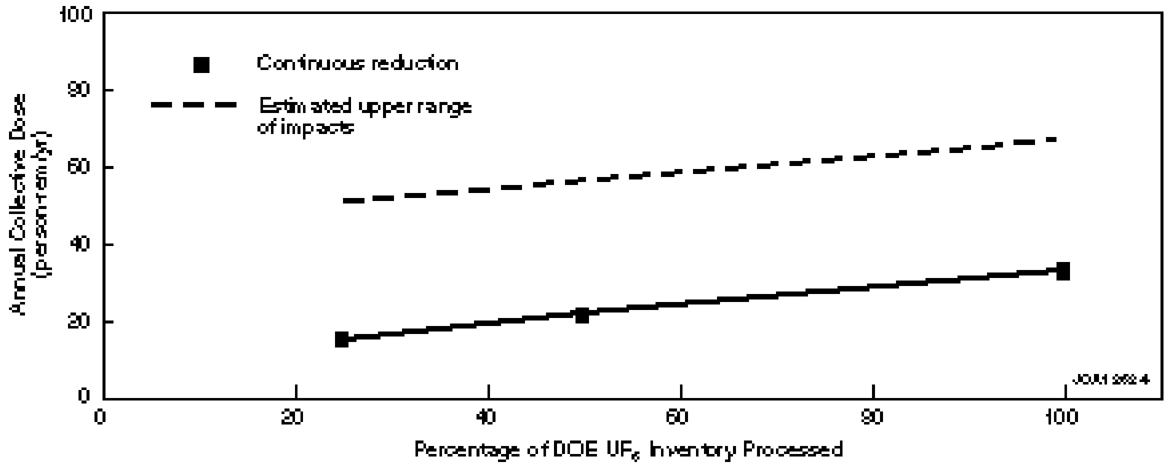

FIGURE K.17 Estimated Annual Collective Dose to Involved Workers from the Conversion of UF_6 to Uranium Metal (The upper and lower ranges reflect differences in conversion technologies.)

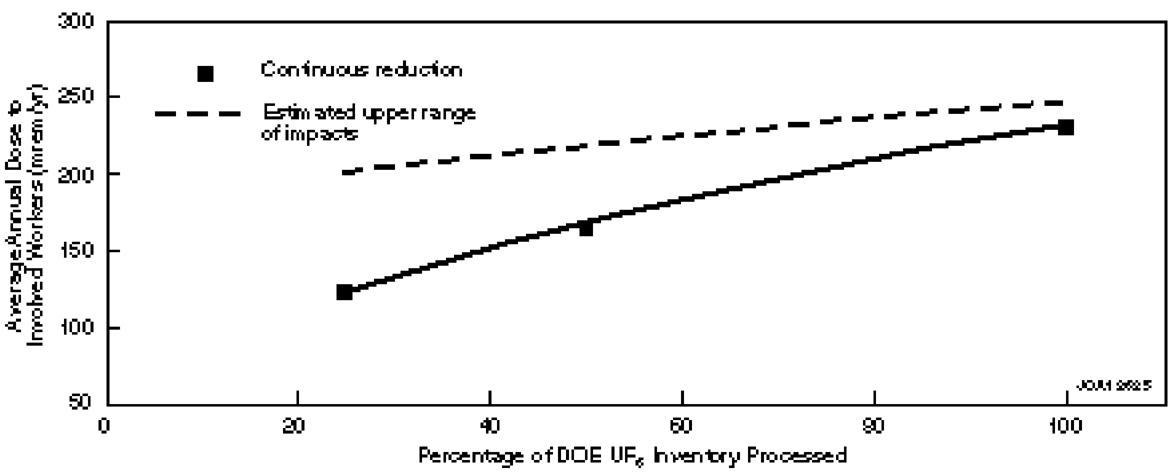

FIGURE K.18 Estimated Annual Average Individual Dose to Involved Workers from the Conversion of UF_6 to Uranium Metal (The upper and lower ranges reflect differences in conversion technologies.)

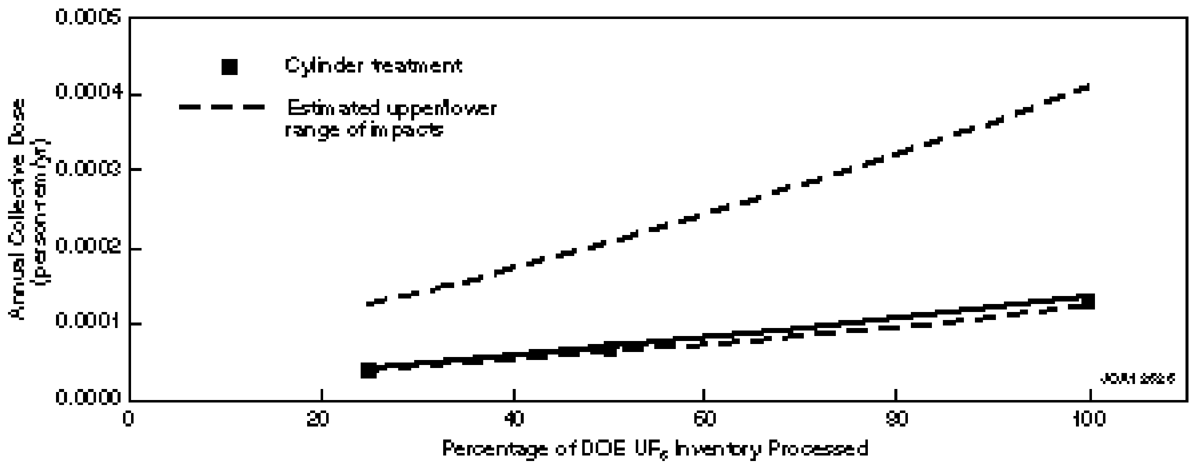

FIGURE K.19 Estimated Annual Collective Dose to Members of the Public from the Cylinder Treatment Facility (The upper and lower ranges reflect differences in representative site characteristics.)

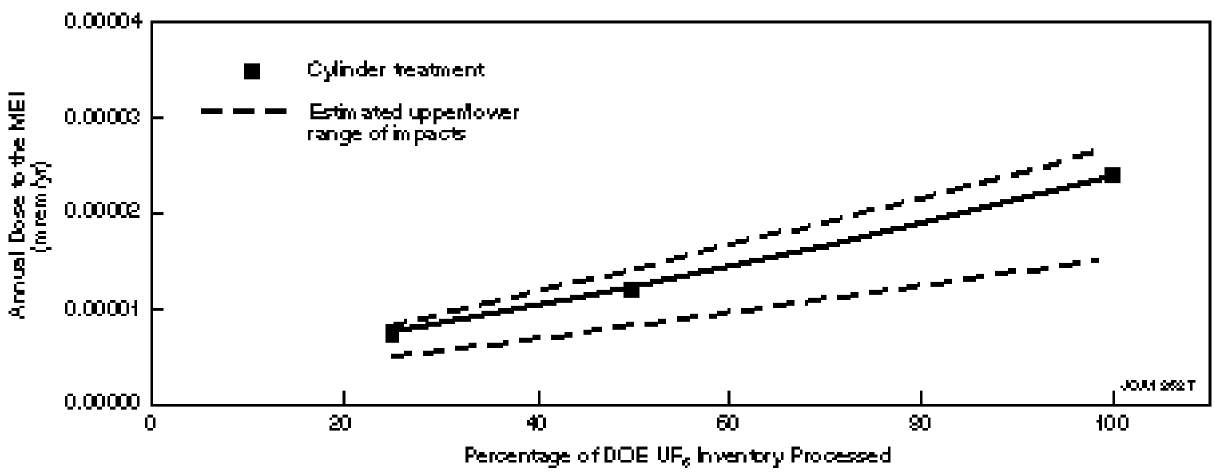

FIGURE K.20 Estimated Annual Dose to the General Public MEI from the Cylinder Treatment Facility (The upper and lower ranges reflect differences in representative site characteristics.)

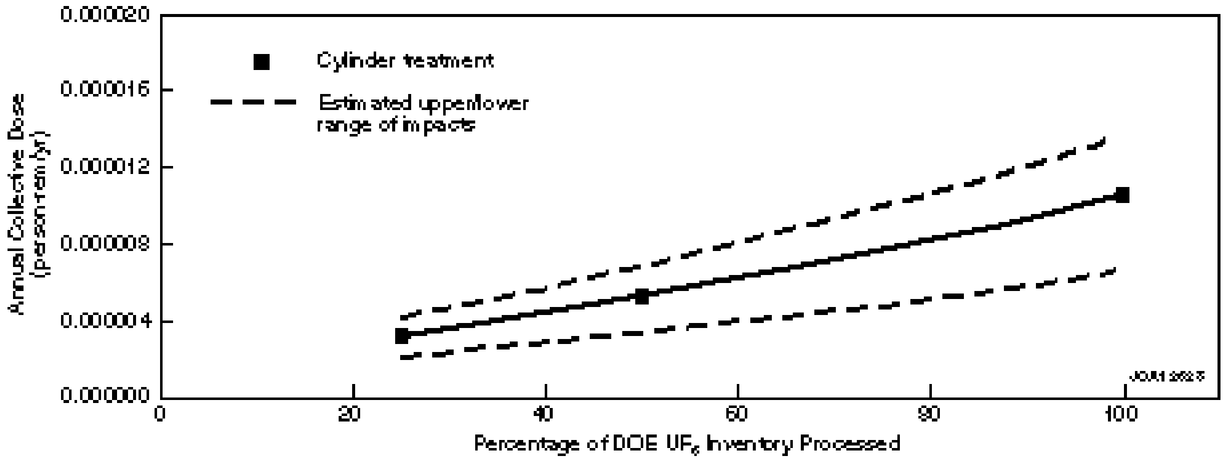

FIGURE K.21 Estimated Annual Collective Dose to Noninvolved Workers from the Cylinder Treatment Facility (The upper and lower ranges reflect differences in representative site characteristics.)

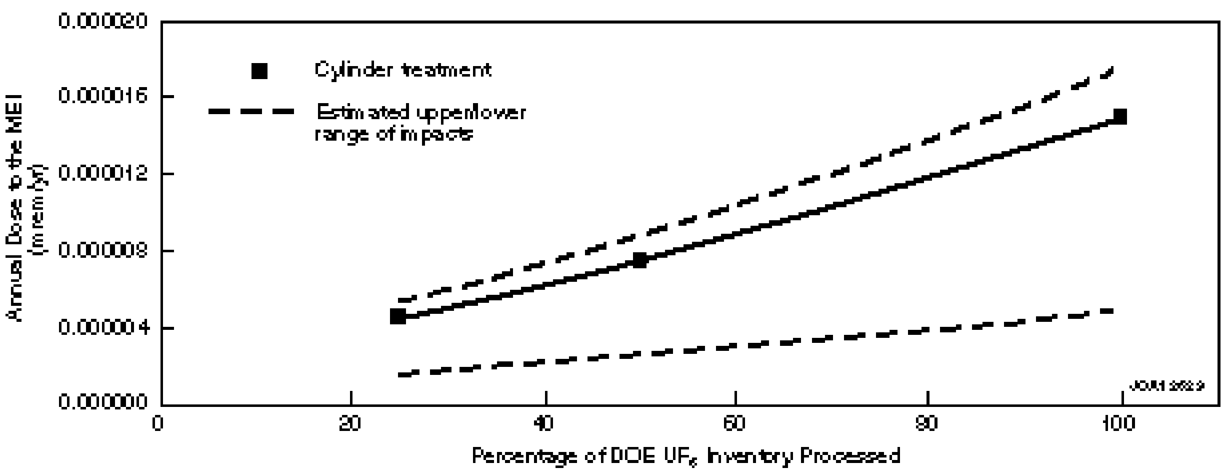

FIGURE K.22 Estimated Annual Dose to the Noninvolved Worker MEI from the Cylinder Treatment Facility (The upper and lower ranges reflect differences in representative site characteristics.)

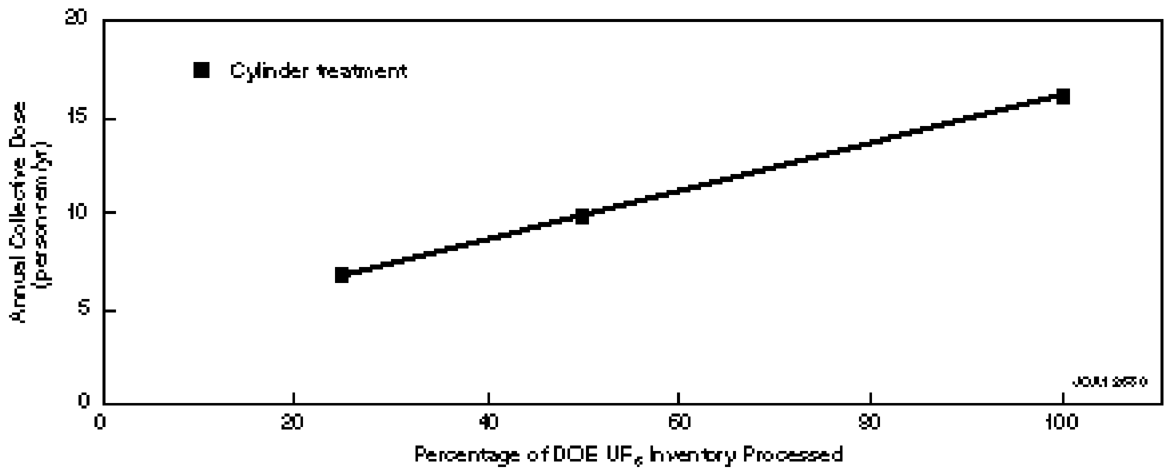

FIGURE K.23 Estimated Annual Collective Dose to Involved Workers from the Cylinder Treatment Facility

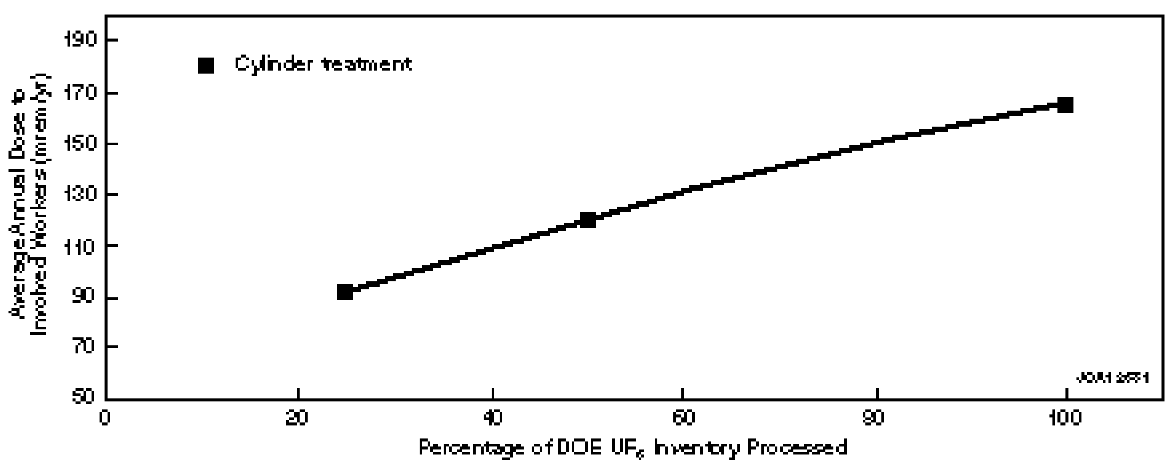

FIGURE K.24 Estimated Annual Average Individual Dose to Involved Workers from the Cylinder Treatment Facility

workers and members of the general public would receive very low exposures to chemicals from operation of the conversion facilities and that no adverse health impacts would be expected. For the 100% cases, the calculated hazard indices were much less than 1 for all three conversion options (a hazard index of greater than 1 indicates the potential for health impacts). For the parametric analysis of the 25% and 50% throughput cases, calculated hazard indices for noninvolved workers and members of the general public were proportionally smaller than those for the 100% cases. Therefore, because the hazard indices are much less than 1, no adverse health impacts from chemical exposures would be expected for throughput rates between 25% and 100%.

The chemical impacts from operations of the cylinder treatment facility were estimated to be less than the impacts from operations of the conversion facilities, therefore resulting in no adverse health impacts to noninvolved workers and the general public for the 25%, 50%, and 100% cases.

K.2.2 Human Health — Accident Conditions

K.2.2.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from potential accidents during operation of the full-scale (100%) conversion facilities are presented in Appendix F, Section F.3.2.1. Analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented only for those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

On the basis of the assessment of the 25% and 50% conversion cases, the radiological accident impacts associated with each of the parametric cases would be the same as those presented for the 100% cases in Appendix F. The impacts would be the same because the bounding accidents within each frequency category (those producing the greatest consequences) would be the same for all cases (100%, 50%, and 25%). The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. Some of the impacts from other accidents considered for the 25% and 50% cases (nonbounding) would be different than those for the 100% cases. In general, the impacts of these nonbounding accidents for the 50% and 25% cases would be less than those for the 100% cases because of the reduced throughput.

All accidents associated with the cylinder treatment facilities discussed in Appendix F would be the same for the parametric analysis (LLNL 1997a). The frequencies of some accidents, such as drum spills, might decrease as the number of drums handled decreased with facility throughput. However, it is not expected that the small changes in frequencies for specific accidents would change the overall frequency category for those accidents. As a result, the accident impacts associated with the cylinder treatment facility would be the same for all parametric cases.

K.2.2.2 Chemical Impacts

The estimated chemical impacts from potential accidents during the operation of full-scale (100%) conversion facilities are presented in Appendix F, Section F.3.2.2. The analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented only for those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

As for the radiological accident impacts, the chemical accidents producing the greatest consequences for the 25% and 50% parametric cases would be the same as those assessed for the 100% cases in Appendix F. The impacts would be similar because the bounding accidents within most frequency categories would be the same for the 100%, 50%, and 25% cases, and in those cases where the accidents were different, no adverse chemical impacts were estimated. The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. Some of the impacts from other accidents considered for the 25% and 50% cases (nonbounding accidents) would be different than those for the 100% cases. In general, the impacts of these other accidents for the 50% and 25% cases would be less than those for the 100% cases because of the reduced throughput.

All accidents associated with the cylinder treatment facilities discussed in Appendix F would be the same for the parametric analysis (LLNL 1997a). The frequencies of some accidents, such as drum spills, might decrease as the number of drums handled decreased with facility throughput. However, it is not expected that the small changes in frequencies for specific accidents would change the overall frequency category for those accidents. As a result, the overall chemical accident impacts associated with cylinder treatment would be the same for all parametric cases.

K.2.2.3 Physical Hazards

The estimated health impacts, such as on-the-job injuries and fatalities, from potential physical accidents during the construction and operation of full-scale (100%) conversion facilities are presented in Appendix F, Section F.3.2.3. The impacts of the 25% and 50% cases would be smaller than those for the 100% cases, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than half of the impacts for the 100% case).

The estimated total fatalities over the entire period of construction and operations for the U_3O_8 conversion options for the 25%, 50%, and 100% cases would be 0.29, 0.32, and 0.35, respectively (both conversion options analyzed resulted in the same fatality estimates). For the UO_2 conversion options, the estimated total fatalities for the 25%, 50%, and 100% cases would range from 0.35 to 0.49, 0.38 to 0.54, and 0.40 to 0.59, respectively. For the metal conversion options, total fatalities for the 25%, 50%, and 100% cases would range from 0.33 to 0.49, 0.36 to 0.52, and 0.4 to 0.55, respectively.

The total numbers of injuries over the entire period of construction and operation of the specific U_3O_8, UO_2, and metal conversion options analyzed parametrically are illustrated by the solid black line in Figures K.25 through K.27. The estimated upper ranges of impacts for all options examined in the PEIS are illustrated by the dotted lines in the figures (because both U_3O_8 options analyzed resulted in the same number of estimated injuries, only one line is shown in Figure K.25). The ranges of predicted injury incidence for the conversion options would be roughly comparable, reflecting the generally similar requirements for constructing and operating the three types of conversion facilities.

The estimated fatalities for the 25%, 50%, and 100% cases of construction and operation of a cylinder treatment facility would be 0.13, 0.16, and 0.19, respectively. The estimated number of injuries over the entire period of construction and operations would range from 122 to 170. The impacts are shown in Figure K.28 for throughputs ranging from 25% to 100%.

K.2.3 Air Quality

The estimated impacts on air quality during construction and operation of full-scale (100%) conversion facilities are presented in detail in Appendix F, Section F.3.3. All of the pollutant concentrations produced by the 100% capacity version of the conversion facilities would be well below their respective air quality standards, with the possible exception of dust emissions during construction. During construction, short-term particulate concentrations were estimated to potentially approach the applicable air quality standards for all options, although the condition would be temporary and minimized by good construction practices. The air quality impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases. During construction, short-term impacts for the parametric cases would be less than those for the 100% cases, and impacts during operations would also be negligible. However, the air quality impacts from operations would not scale proportionally with facility capacities. The impacts from a 25% capacity plant would be from about 45% to 100% of those from the full-capacity plant, depending on the specific source of the emissions.

All of the pollutant concentrations produced by the 100% capacity version of the cylinder treatment facility would be well below the respective air quality standards (see Appendix F, Section F.3.3). The air quality impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

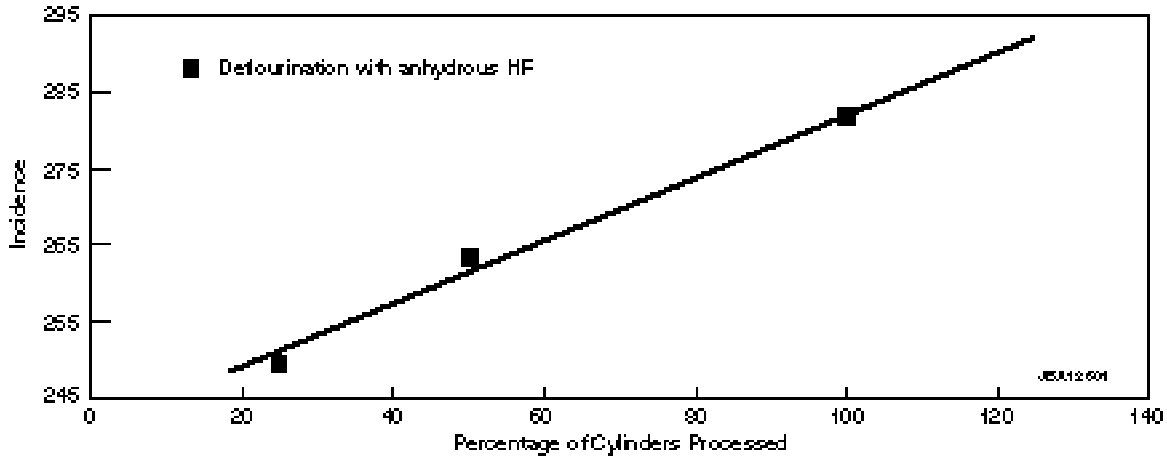

FIGURE K.25 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for the Conversion of UF$_6$ to U$_3$O$_8$ (No range is presented because the number of injuries would be almost identical between the U$_3$O$_8$ conversion technologies.)

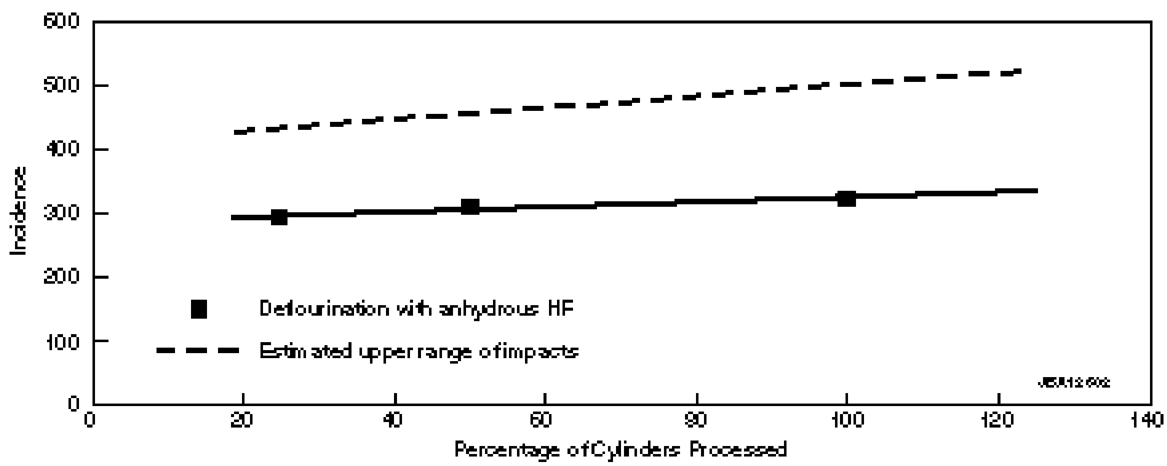

FIGURE K.26 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for the Conversion of UF$_6$ to UO$_2$ (The ranges reflect differences in UO$_2$ conversion technologies.)

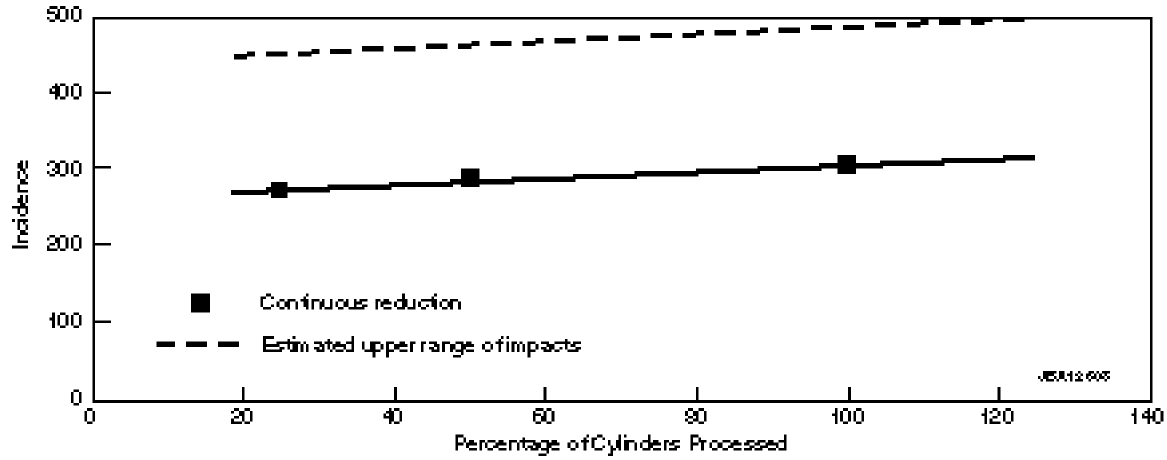

FIGURE K.27 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for the Conversion of UF_6 to Uranium Metal (The ranges reflect differences in uranium metal conversion technologies.)

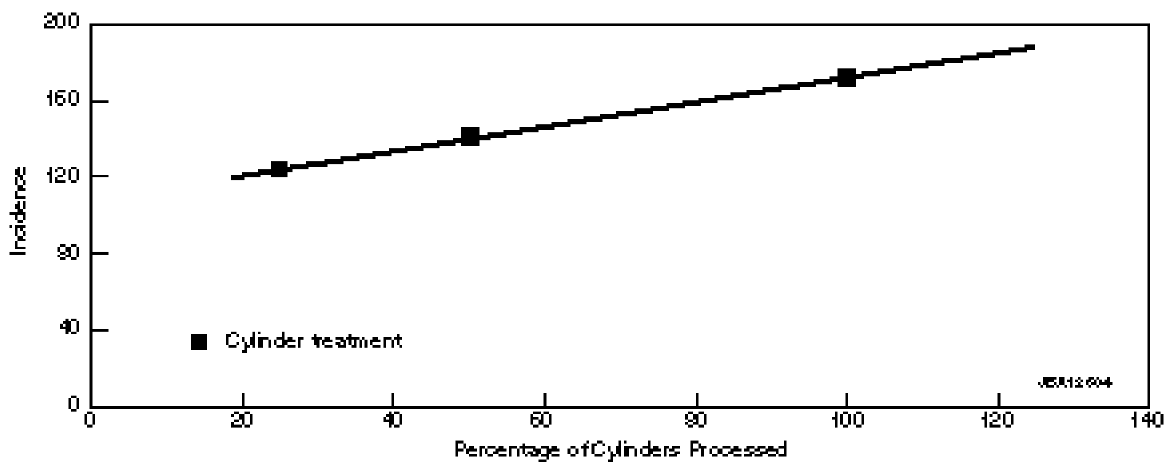

FIGURE K.28 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for the Cylinder Treatment Facility

K.2.4 Water and Soil

K.2.4.1 Surface Water

The estimated impacts on surface water during construction, operation, and potential accidents for full-scale (100%) conversion facilities and the cylinder treatment facility are presented in detail in Appendix F, Section F.3.4.1. The potential impacts evaluated included changes in runoff, changes in quality, and floodplain encroachment. The impacts to surface water from the 100% cases were found to be negligible for all three conversion options. The impacts to surface water estimated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.2.4.2 Groundwater

The estimated impacts on groundwater during construction, operation, and potential accidents for full-scale (100%) conversion facilities and the cylinder treatment facility are presented in detail in Appendix F, Section F.3.4.2. The potential impacts evaluated included changes in the depth to groundwater, the direction of groundwater flow, recharge, and quality. The impacts to groundwater from the 100% cases were found to be negligible for all three conversion options. The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.2.4.3 Soil

The estimated impacts to soil during construction, operation, and potential accidents for full-scale (100%) conversion facilities and the cylinder treatment facility are presented in detail in Appendix F, Section F.3.4.3. The potential impacts evaluated included changes in topography, permeability, quality, and erosion potential. The impacts to soil from the 100% cases were found to be negligible for all three conversion options. The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.2.5 Socioeconomics

The socioeconomic impacts of U_3O_8, UO_2, and metal conversion and cylinder treatment facilities for the 50% and 25% parametric cases would be less than the impacts of the base-case facility sizes. Cost information was not available in sufficient detail to allow an analysis of impacts using the same methodology that was used for the base cases. The impacts of parametric cases were therefore assessed qualitatively, based on the assumption that changes in the cost of equipment, materials, and labor between cases would be proportional to changes in total life-cycle cost. Compared with base-case facility sizes, smaller conversion and cylinder treatment facilities would result in the following: less direct and indirect employment and income would be created in the region of influence (ROI) at each representative site; fewer people would migrate into the ROI with fewer total jobs created, meaning fewer rental and owner-occupied houses would be needed; and the impact on local jurisdictional revenues and expenditures would be smaller.

K.2.6 Ecology

Site preparation for the construction of conversion and cylinder treatment facilities would result in the disturbance of biotic communities, including the permanent replacement of habitat with structures, paved areas, and landscaping (see Section K.2.9). Existing vegetation would be destroyed during land-clearing activities. Wildlife would be disturbed by land clearing, noise, and human presence.

Normal operations of the conversion facility would generate minor atmospheric emissions of criteria pollutants, HF, and uranium compounds. However, resulting air concentrations would be expected to be negligible under all three cases analyzed, resulting in negligible impacts to ecological resources.

Effluent discharges to surface water would contain low levels of contaminants, including uranium. However, under all three cases, contaminant concentrations in the undiluted effluent would be below levels that adversely affect aquatic biota.

Depending on the exact location of the conversion facility, the loss of approximately 10 to 30 acres (4 to 12 ha) of undeveloped land and habitat, representing the rounded 25-100% capacity range for oxide and metal conversion facilities, might constitute a minor to moderate adverse impact to vegetation and wildlife. For the cylinder treatment facility, the loss of 6.8 to 8.7 acres (2.8 to 3.5 ha) of undeveloped land and the permanent loss of 3.2 to 4.5 acres (1.3 to 1.8 ha) of habitat would constitute a negligible to low adverse impact. (See Section K.2.9 for details on land use assumptions.) When these facilities would be sited, all appropriate measures would be taken to preclude or minimize such impacts.

Impacts to wetlands and state and federally protected species due to facility construction would depend on facility location. Avoidance of wetland areas would be included during facility planning. Impacts to air quality, surface water, groundwater, and soil during construction and operations would be expected to be negligible, as would the resulting derived impacts to ecological resources.

K.2.7 Waste Management

The estimated impacts from waste management operations for construction and operation of full-scale (100%) conversion facilities are presented in detail in Appendix F, Section F.3.7. Potential moderate impacts to site, regional, and national waste management operations were found for all 100% throughput conversion option cases. On the basis of information provided in the engineering analysis report (LLNL 1997a), the impacts resulting from construction and operation of the conversion facility for the 25% and 50% parametric cases would be roughly linear for throughput ranges of between 25% and 100%. Minimal waste management impacts would result from construction-generated wastes. The annual amounts of waste generated during facility operations are shown in Table K.2. Overall, the waste input resulting from normal operations at the conversion facilities would have a low to moderate impact on waste management capacities locally or across the DOE complex.

There is a significant possibility that the magnesium fluoride (MgF_2) waste generated in the conversion to metal option would be sufficiently contaminated with uranium to require disposal as low-level radioactive waste (LLW) rather than as solid nonhazardous waste. Such disposal might require the MgF_2 waste to be grouted, generating up to 12,300 m^3/yr of grouted waste for LLW disposal. This volume represents a low (5.8%) impact to the DOE complexwide LLW disposal capacity for the 100% throughput case (scales linearly for the three throughput cases).

K.2.8 Resource Requirements

The estimated impacts from resource requirements during construction and operation of full-scale (100%) conversion facilities are presented in detail in Appendix F, Section F.3.8. The impacts on resources would be expected to be small for the 100% capacity conversion case. Although the resource requirements for the two conversion parametric analyses would be less than the 100% case, the reduction in requirements would not be linearly proportional to the decrease in throughput. For example, the amount of material required to construct a conversion facility for the 25% throughput case would be only about 10% to 20% less than the amount required for the 100% throughput facility due to “economies-of-scale.”

Construction and operation of the proposed conversion options would consume irretrievable amounts of electricity, fuel, concrete, steel and other metals, water, and miscellaneous chemicals. The total quantities of commonly used materials would not be expected to be significant. No strategic and critical materials (e.g., Monel or Inconel) in significant quantities are projected to be consumed during construction or operation. The conversion options are not considered resource-intensive, and the resources required are generally not considered rare or unique. Furthermore, committing any of these resources would not be expected to cause a negative impact on the availability of these resources within local areas or nationally for the 100%, 50%, and 25% cases.

TABLE K.2 Waste Generation from Conversion Facilities for 100%, 50%, and 25% Throughput Cases

	Waste Generated (m^3/yr) by Conversion to U_3O_8, UO_2, or Uranium Metal for Three Throughput Cases								
	U_3O_8			UO_2			Uranium Metal		
Waste Category	100%	50%	25%	100%	50%	25%	100%	50%	25%
Low-level radioactive waste									
Combustible	77	73	70	88	84	82	77	71	69
Noncombustible	62	45	33	82	63	45	112	88	69
Grouted	466	233	116	466	233	116	37	26	18
Low-level mixed waste	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Hazardous waste	7.3	6.7	6.1	7.3	6.7	6.1	7.3	6.7	6.1
Nonhazardous waste									
Solids	535	512	490	612	585	566	6,680[a]	3,590[a]	2,040[a]
Wastewater	58,000	36,300	24,600	74,900	47,300	31,000	96,500	57,500	37,500
Sanitary waste	4,920	4,730	4,540	5,680	5,380	5,220	5,300	4,950	4,800

[a] Includes the following volumes of MgF_2 waste: 6,120 m^3/yr for the 100% case; 3,060 m^3/yr for the 50% case, and 1,530 m^3/yr for the 25% case.

Construction and operation of a cylinder treatment facility would also consume irretrievable amounts of electricity, fuel, concrete, steel, water, and miscellaneous gases and chemicals. Similar to the conversion facilities, the cylinder treatment facility option would not be expected to result in negative impacts relative to its resource requirements.

K.2.9 Land Use

K.2.9.1 Conversion to U_3O_8

Potential impacts to land use from the construction and operation of a U_3O_8 conversion facility would include the acquisition and clearing of required land, minor and temporary disruptions to contiguous land parcels, and increases in vehicular traffic. Site preparation for the construction of a facility to convert 25%, 50%, and 100% of the depleted UF_6 inventory to U_3O_8 by defluorination with anhydrous HF would require the disturbance of approximately 14, 16, and 20 acres (5.5, 6.4, and 8.1 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 9, 11, and 13 acres (3.6, 4.2, and 5.3 ha) with structures, paved areas, and landscaping. The amount of land required for the other U_3O_8 conversion technologies would be roughly similar. Even the highest areal requirement would not be great enough to generate other than negligible, temporary disturbance impacts, particularly if the facility was sited in a location already dedicated to similar use with immediate access to infrastructure and utility support.

Impacts to land use outside the boundaries of a U_3O_8 conversion facility at 25%, 50%, or 100% of throughput would be limited to negligible, temporary traffic impacts associated with project construction.

K.2.9.2 Conversion to UO_2

Impacts to land use from the construction and operation of a UO_2 conversion facility, regardless of throughput capacity case, would be negligible and limited to minor and temporary disruptions to contiguous land parcels and increases in vehicular traffic associated with construction activities. Site preparation for the construction of a facility to convert 25%, 50%, and 100% of the depleted UF_6 inventory to UO_2 by the dry process with anhydrous HF would require the disturbance of approximately 16, 19, and 24 acres (6.4, 7.9, and 9.7 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 10, 13, and 15 acres (4.0, 5.2, and 5.9 ha) with structures, paved areas, and landscaping. The amount of land required for the other UO_2 conversion technologies would be roughly similar, except for gelation, which would require a slightly greater amount of land. Even the highest areal requirement would not be great enough to generate other than negligible, temporary disturbance impacts associated with construction.

Impacts to land use outside the boundaries of a UO_2 conversion facility at 25%, 50%, or 100% of throughput would be limited to minor, temporary traffic impacts associated with project construction.

K.2.9.3 Conversion to Uranium Metal

Impacts to land use from the construction and operation of a facility for uranium metal conversion, regardless of throughput capacity case, would be negligible and limited to minor and temporary disruptions to contiguous land parcels and increases in vehicular traffic associated with construction activities. Site preparation for the construction of a facility to convert 25%, 50%, and 100% of the depleted UF_6 inventory to uranium metal by the continuous metallothermic production technology would require the disturbance of approximately 17, 21, and 26 acres (6.8, 8.6, and 10.6 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 12, 14, and 15 acres (4.8, 5.5, and 6.2 ha) with structures, paved areas, and landscaping. The amount of land required for the other uranium metal conversion technology would be roughly similar. Even the highest areal requirement would not be great enough to generate other than negligible, temporary disturbance impacts associated with construction.

Impacts to land use outside the boundaries of a conversion-to-metal facility at 25%, 50%, or 100% of throughput would be limited to minor, temporary traffic impacts associated with project construction.

K.2.9.4 Cylinder Treatment Facility

Other than negligible and temporary disruptions to contiguous land parcels, and slight increases in vehicular traffic, virtually no impacts would be expected from a cylinder treatment facility at 25%, 50%, or 100% of throughput capacity. Site preparation for construction of a stand-alone cylinder treatment facility for 25%, 50%, and 100% of the depleted UF_6 inventory would require the disturbance of approximately 6.8, 7.5, and 8.7 acres (2.8, 3.0, and 3.5 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 3.2, 3.7, and 4.5 acres (1.3, 1.5, and 1.8 ha) with structures and paved areas.

Potential impacts to land use outside the boundaries of a site containing a cylinder treatment facility at 25%, 50%, or 100% of throughput capacity would be limited to negligible, temporary traffic impacts associated with project construction.

K.2.10 Other Impacts Considered But Not Analyzed in Detail

Other impacts could potentially occur if the conversion options considered in this PEIS were implemented — including impacts to cultural resources and environmental justice, as well as to aesthetics (e.g., visual environment), recreational resources, and noise levels, and impacts associated with decontamination and decommissioning of conversion facilities. These impacts, although considered, were not analyzed in detail for one or both of the following reasons:

- The impacts could not be determined at the programmatic level without consideration of specific sites. These impacts would be more appropriately addressed in the second-tier *National Environmental Policy Act* (NEPA) documentation when specific sites are considered.

- Consideration of the impacts would not contribute to differentiation among the alternatives; therefore, it would not affect the decisions to be made in the Record of Decision that will be issued following publication of this PEIS.

K.3 LONG-TERM STORAGE OPTIONS

The parametric analysis of the long-term storage options considered the environmental impacts of storing 25% and 50% of the depleted UF_6 inventory as UF_6 or as an oxide form. In both cases, it was assumed that the uranium material would be actively placed into storage over a 20-year period (from 2009 through 2028), and then stored for an additional 11-year period (from 2029 through 2039) with only routine monitoring and maintenance. The assessment considered the environmental impacts that would occur during (1) construction of a storage facility, (2) routine operations, and (3) potential storage facility accidents. The areas of impact and the methodologies used to evaluate the parametric cases were the same as those used to evaluate the 100% cases discussed in detail in Appendix G. The supporting engineering data for the 25% and 50% parametric storage cases are provided in the engineering analysis report (LLNL 1997a).

The environmental impacts for the 100% case are presented in Appendix G for (1) storage as UF_6 in yards, buildings, and an underground mine; (2) storage as U_3O_8 in buildings, vaults, and a mine; and (3) storage as UO_2 in buildings, vaults, and a mine. For the purposes of the parametric analysis, storage as UF_6 in buildings and storage as UO_2 in buildings were considered in detail. These options were chosen to simplify the parametric analysis because all options were evaluated in detail for the 100% base case. The relationships between the options that were identified for the 100% case were used to infer the impacts for all of the long-term storage options for the parametric analysis.

K.3.1 Human Health — Normal Operations

K.3.1.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from the normal operation of full-scale (100%) storage facilities for depleted UF_6 cylinders, UO_2 drums, and U_3O_8 drums are described in Appendix G, Section G.3.1.1. Similar impacts were calculated for the 50% and 25% storage facilities for the parametric analysis. Radiological impacts from the storage as UF_6, UO_2, and U_3O_8 would be limited to involved workers because emissions of uranium to the air and water would be expected to be negligible during normal operations. The radiological impacts for involved workers for the 100%, 50%, and 25% cases are shown in Figures K.29 through K.34. The range of impacts resulting from technology differences (i.e., differences between building, vault, and mine storage facilities) are represented by dashed lines in the figures. The results for the two parametric cases for storage in buildings are shown in the figures as solid points, with a curve drawn between the points to indicate how the impacts would vary as a function of the percent of depleted UF_6 processed. The upper and lower bounds of impacts for the 25% and 50% cases were estimated on the basis of the range determined for the different technologies for the 100% case. The area enclosed by the lines in the figures indicates the range of impacts expected for throughputs between 25% and 100%.

The results of the parametric analysis (as shown in Figures K.29 and K.34) indicate that the collective radiological impacts would scale relatively linearly with the total quantity of depleted UF_6 processed. The impacts of the 25% and 50% cases would be smaller than those for the 100% case, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than half of the impacts for the 100% case). The doses shown in the figures can be converted to the number (or risk) of LCFs by multiplying the doses (in rem or person-rem) by 0.0004 LCF/person-rem for workers. Additional discussion of the significance of the estimated doses is provided in Appendix G, Section G.3.1.1.

K.3.1.2 Chemical Impacts

The estimated impacts from chemical exposures during the normal operation of full-scale (100%) storage facilities are described in Appendix G, Section G.3.1.2. The results of the 100% case analyses indicated that noninvolved workers and members of the general public would receive very low exposures to chemicals from operation of all storage facilities and that no adverse health impacts would be expected. For the 100% cases, the calculated hazard indices were much less than 1 for all long-term storage options (a hazard index of greater than 1 indicates the potential for health impacts). For the parametric analysis of the 25% and 50% throughput cases, airborne emissions of depleted uranium and HF during normal operations would be less than the 100% cases and extremely small (LLNL 1997a). Therefore, by comparison with the

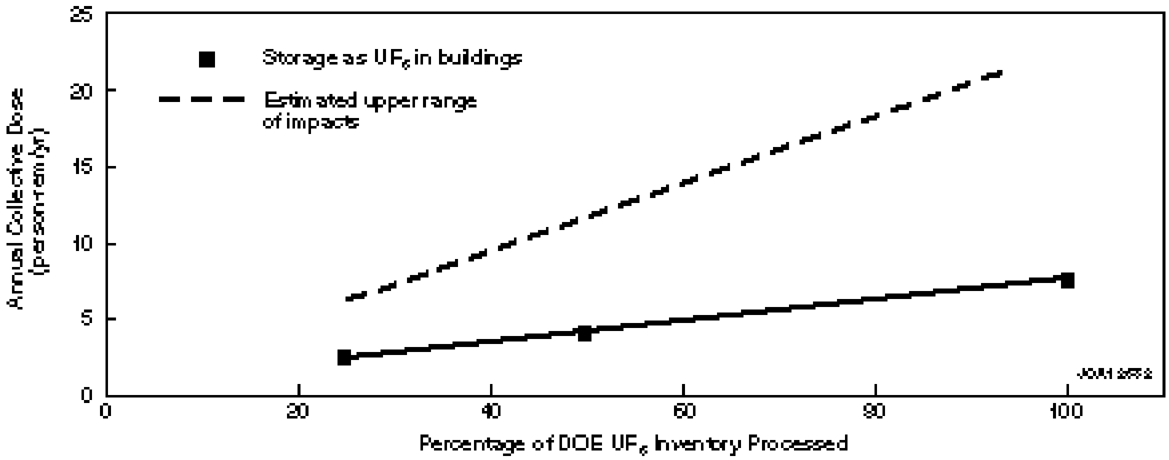

FIGURE K.29 Estimated Annual Collective Dose to Involved Workers from Storage as UF_6 (The upper and lower ranges reflect differences in storage technologies, i.e., buildings, yards, and mine.)

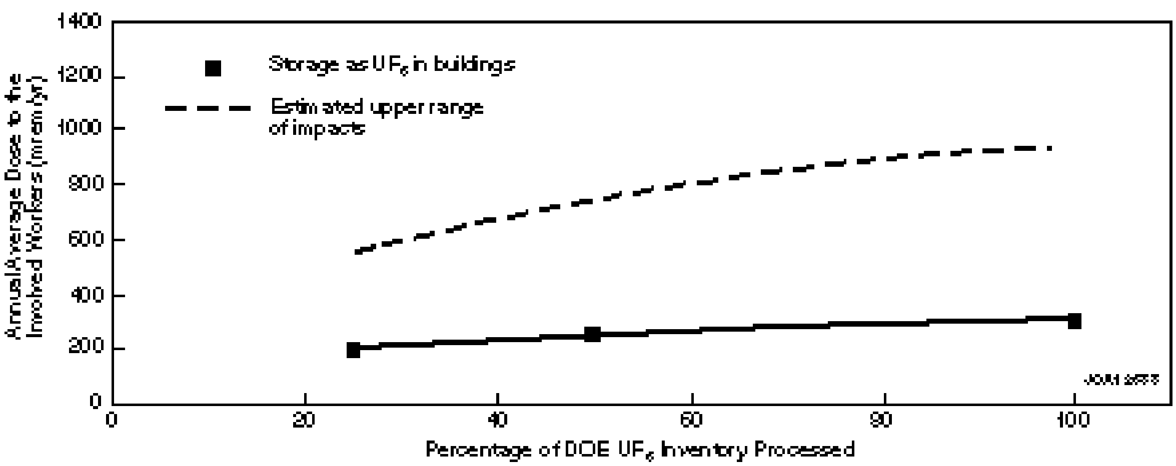

FIGURE K.30 Estimated Annual Average Individual Dose to Involved Workers from Storage as UF_6 (The upper and lower ranges reflect differences in storage technologies, i.e., buildings, yards, and mine.)

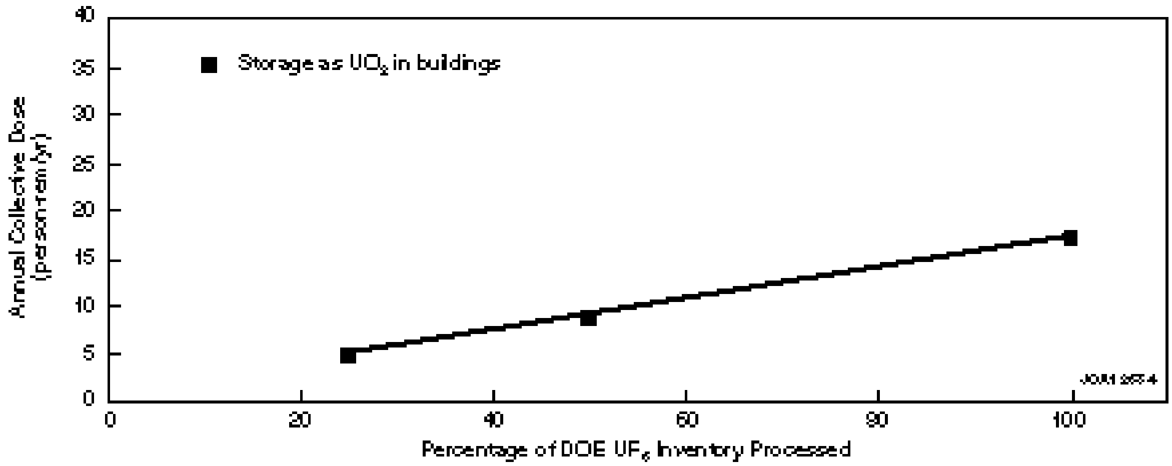

FIGURE K.31 Estimated Annual Collective Dose to Involved Workers from Storage as UO_2 (The collective doses for the different storage technologies would be essentially the same.)

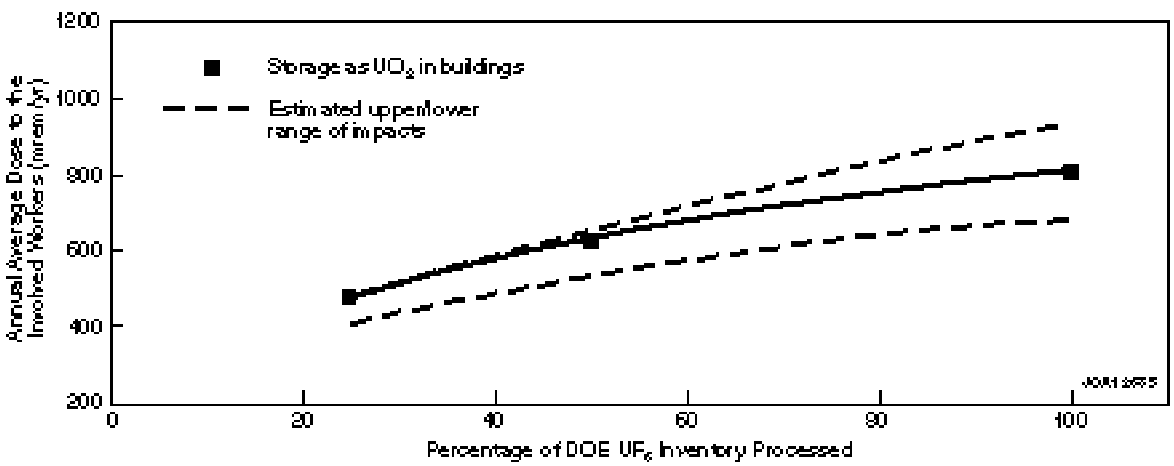

FIGURE K.32 Estimated Annual Average Individual Dose to Involved Workers from Storage as UO_2 (The upper and lower ranges reflect differences in storage technologies, i.e., buildings, vaults, and mine.)

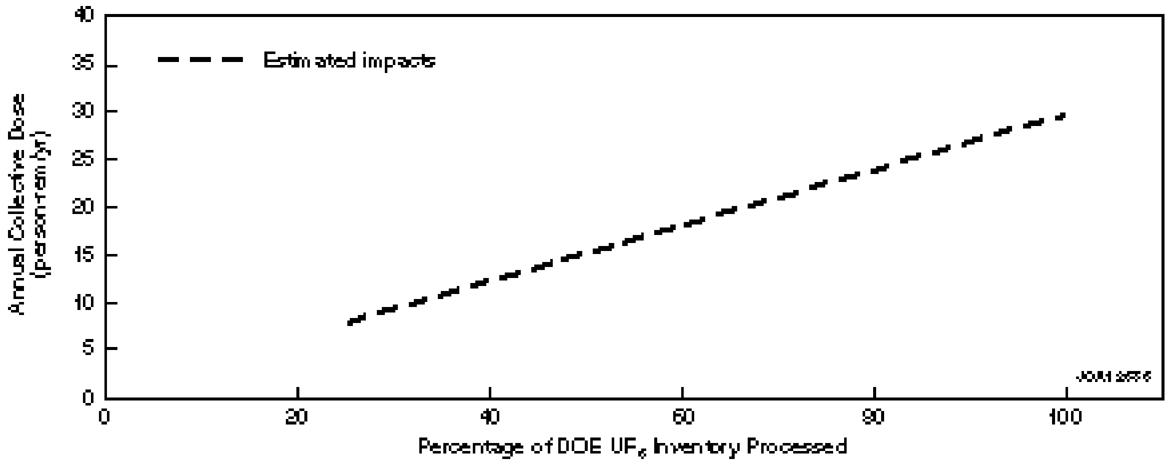

FIGURE K.33 Estimated Annual Collective Dose to Involved Workers from Storage as U_3O_8

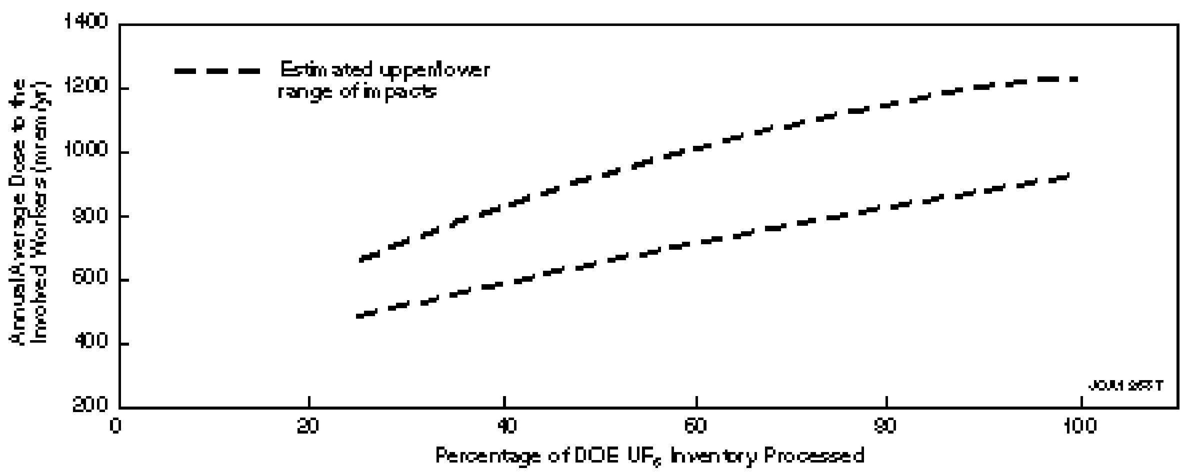

FIGURE K.34 Estimated Annual Average Individual Dose to Involved Workers from Storage as U_3O_8 (The upper and lower ranges reflect differences in storage technologies, i.e., buildings, vaults, and mine.)

100% case results, no adverse health impacts from chemical exposures would be expected for throughput rates between 25% and 100% for all long-term storage options.

K.3.2 Human Health — Accident Conditions

K.3.2.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from potential accidents during the operation of full-scale (100%) storage facilities for depleted UF_6, U_3O_8, and UO_2 are presented in Appendix G, Section G.3.2.1. The analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented for only those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

Based on the assessment of the 25% and 50% long-term storage cases, the radiological accident impacts associated with each of the parametric cases would be the same as those presented for the 100% case in Appendix G, Section G.3.2.1. The impacts would be identical because the bounding accidents within each frequency category would be the same for the 100%, 50%, and 25% cases. The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. However, as a result of the reduced throughput rates, the actual frequencies of some accidents that were related to handling operations (i.e., the “mishandle/drop of drum” accident) would decrease as the number of containers handled decreased. The resulting risk of these accidents would also decrease as their frequencies decreased. However, none of the accident frequencies would change enough to cause the accident to be considered in a different frequency category. Therefore, the overall impacts associated with the long-term storage options would be the same for all parametric cases.

K.3.2.2 Chemical Impacts

The estimated chemical impacts from potential accidents during the operation of full-scale (100%) storage facilities for UF_6 and oxide are presented in Appendix G, Section G.3.2.2. The analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented for only those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

Based on the assessment of the 25% and 50% long-term storage cases, the chemical accident impacts associated with each of the parametric cases would be the same as those presented for the 100% case in Appendix G, Section G.3.2.2. As for radiological accidents, the impacts would be the same because the bounding accidents within each frequency category would be the same for the 100%, 50%, and 25% cases. The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. However, as a result of the reduced throughput rates, the actual frequencies of some accidents related to handling operations (i.e., the "mishandle/drop of drum" accident) would decrease as the number of containers handled decreased. The resulting risk of these accidents would also decrease as their frequencies decreased. However, none of the accident frequencies would change enough to cause the accident to be considered in a different frequency category. Therefore, the overall impacts associated with the long-term storage options would be the same for all parametric cases.

K.3.2.3 Physical Hazards

The estimated health impacts, such as on-the-job injuries and fatalities, from potential physical accidents during the construction and operation of full-scale (100%) storage facilities are presented in Appendix G, Section G.3.2.3. For the 100% storage cases, worker fatalities ranged from about 0.10 to 0.36 for storage as UF_6, 0.16 to 0.24 for storage as UO_2, and 0.29 to 0.43 for storage as U_3O_8 (see Table G.11 in Section G.3.2.3). On-the-job worker injuries for the 100% cases ranged from about 90 to 190 for storage as UF_6, from 150 to 220 for storage as U_3O_8, and from 100 to 140 for storage as UO_2. For the two options analyzed in detail in the parametric analysis, the impacts of the 25% and 50% cases would be smaller than those for the 100% cases, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than 50% of the impacts for the 100% case).

For parametric cases, the number of on-the-job worker fatalities for storage as UF_6 would range from 0.05 to 0.23 at 25% capacity and from about 0.10 to 0.29 at 50% capacity. For storage as UO_2, fatalities would range from 0.07 to 0.15 at 25% capacity and from about 0.10 to 0.19 at 50% capacity. The number of on-the-job worker injuries for storage as UF_6 would range from about 50 to 125 at 25% capacity and from about 60 to 150 at 50% capacity. For storage as UO_2, injuries would range from about 50 to 90 at 25% capacity and from about 75 to 110 at 50% capacity. The predicted number of injuries for UF_6 and UO_2 are shown as a function of throughput in Figures K.35 and K.36, respectively.

Although parametric cases for the U_3O_8 storage options were not explicitly analyzed, if it is assumed that the relative difference in magnitude of impacts for U_3O_8 and UO_2 is similar to that for the 100% cases, then the number of on-the-job fatalities for storage as U_3O_8 would range from about 0.12 to 0.26 for 25% capacity and from about 0.19 to 0.36 at 50% capacity. Estimated injuries for parametric cases of storage as U_3O_8 would range from about 75 to 135 for 25% capacity and from about 113 to 176 for 50% capacity.

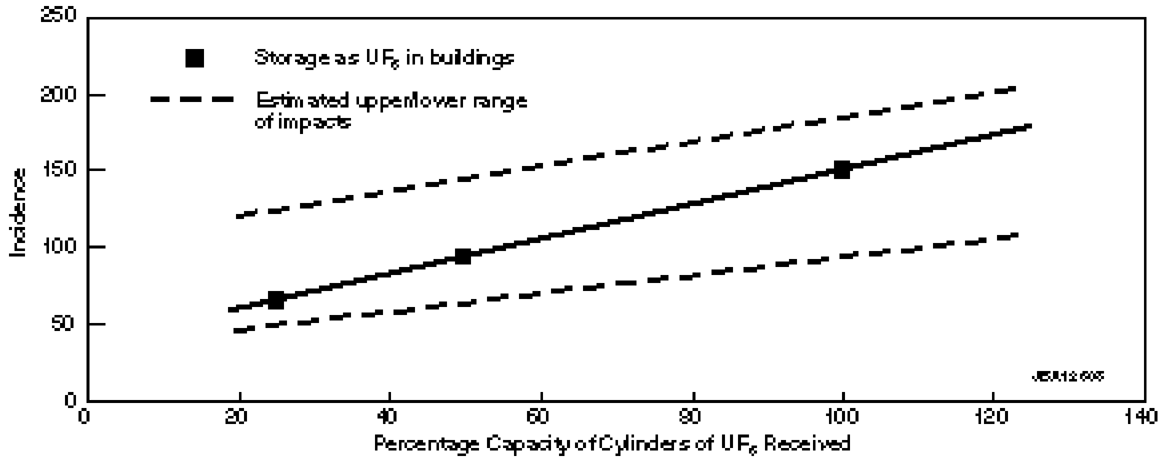

FIGURE K.35 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for Storage as UF_6 (The ranges reflect differences in storage technologies, i.e., buildings, yards, and mine.)

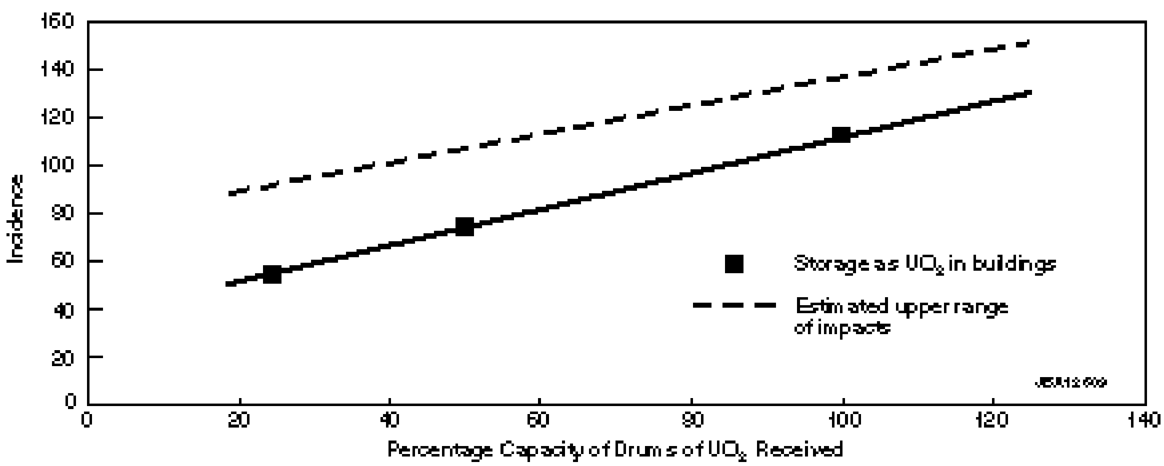

FIGURE K.36 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) for Storage as UO_2 (The ranges reflect differences in storage technologies, i.e., buildings, vaults, and mine.)

K.3.3 Air Quality

The estimated impacts on air quality during construction and operation of full-scale (100%) long-term storage facilities for UF_6 and oxide are presented in detail in Appendix G, Section G.3.3. All of the pollutant concentrations resulting from 100% throughput would be below the respective air quality standards. During construction, short-term particulate concentrations would potentially approach the applicable air quality standards for all options, although the condition would be temporary and minimized by good construction practices. During operations, the pollutant concentrations would be less than 0.1% of the corresponding air quality standards, resulting in negligible impacts.

The air quality impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases. During construction, short-term impacts for the parametric cases would be less than those for the 100% cases; impacts during operations would also be negligible. The air quality impacts from storage were found to scale roughly proportionally with throughput. The impacts from the 50% case for both construction and operations would be about 0.6 of those from the 100% case for both UF_6 and UO_2; the impacts for construction for the 25% case would be 0.25 and 0.32 times the 100% case for UF_6 and UO_2, respectively; and the impacts for operations for the 25% case would be only about 0.2 times the 100% case for both UF_6 and UO_2.

K.3.4 Water and Soil

K.3.4.1 Surface Water

The estimated impacts on surface water during construction, operation, and potential accidents for full-scale (100%) storage facilities for UF_6 and oxide are presented in detail in Appendix G, Section G.3.4.1. The potential impacts evaluated included changes in runoff, changes in quality, and floodplain encroachment. The impacts to surface water from the 100% cases were found to be negligible for all storage options for both UF_6 and oxide (including storage of U_3O_8). The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.3.4.2 Groundwater

The estimated impacts on groundwater during construction, operation, and potential accidents for full-scale (100%) storage facilities for UF_6 and oxide are presented in detail in Appendix G, Section G.3.4.2. The potential impacts evaluated included changes in depth to groundwater, direction of groundwater flow, recharge, and groundwater quality. The impacts to groundwater from the 100% cases were found to be negligible for all storage options for both UF_6

and oxide (including storage of U_3O_8). The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.3.4.3 Soil

The estimated impacts to soil during construction, operation, and potential accidents for full-scale (100%) long-term storage facilities for UF_6 and oxide are presented in detail in Appendix G, Section G.3.4.3. The potential impacts evaluated included changes in topography, permeability, quality, and erosion potential. The impacts to soil from the 100% cases were found to have potentially moderate, but temporary, impacts for all storage options. These moderate impacts would result from material excavated during construction that would be left on-site. In the long term, contouring and reseeding would return soil conditions back to their former state, and the impacts would be negligible. The impacts calculated for the 25% and 50% parametric cases for storage of UF_6 and UO_2 in buildings, based on information provided in the engineering analysis report (LLNL 1997a), were also found to have moderate, but temporary, impacts on soil, similar to the 100% cases. In the long term, impacts on soil would be negligible for all storage options.

K.3.5 Socioeconomics

The socioeconomic impacts of UF_6 and UO_2 long-term storage facilities for the 50% and 25% parametric cases would be less than the impacts of the base-case facility sizes. Cost information was not available in sufficient detail to allow an analysis of impacts using the same methodology that was used for the base cases. The impacts of parametric cases were therefore assessed qualitatively, based on the assumption that changes in the cost of equipment, materials, and labor would be proportional to changes in total life-cycle cost. Compared with base-case facility sizes, smaller UF_6 and UO_2 long-term storage facilities would result in the following: less direct and indirect employment and income in the ROI would be created at each representative site; fewer people would migrate into the ROI with fewer total jobs created, meaning fewer rental and owner-occupied houses would be needed; and the impact on local jurisdictional revenues and expenditures would be smaller.

K.3.6 Ecology

Impacts to ecological resources could occur during construction of UF_6 storage facilities for all options, although impacts during operations would be negligible. Impacts due to construction and operation of a facility to store UO_2 in buildings would be similar to impacts from storage of UF_6. Site preparation activities would result in the disturbance of biotic communities, including the permanent replacement of habitat with structures and paved areas (see

Section K.3.9). Existing vegetation would be destroyed during land-clearing activities. Wildlife would be disturbed by land clearing, noise, and human presence.

Depending on the exact location of the UF_6 facility, the loss of 40 to 130 acres (16 to 53 ha) of undeveloped land and habitat might constitute a moderate to large adverse impact to vegetation and wildlife. (See Section K.3.9 for details on land use assumptions.) Depending on the exact location of the UO_2 facility, the loss of 40 to 80 acres (16 to 32 ha) of undeveloped land and habitat might constitute a moderate adverse impact. However, when these facilities were sited, all appropriate measures would be taken to preclude or minimize such impacts.

Impacts to wetlands and state and federally protected species due to facility construction would depend on facility location. Avoidance of wetland areas and site-specific surveys for protected species would be included during facility planning.

K.3.7 Waste Management

The estimated impacts from waste management operations from the construction and operation of full-scale (100%) long-term storage facilities for UF_6 and oxide are presented in detail in Appendix G, Section G.3.7. On the basis of information provided in the engineering analysis report (LLNL 1997a), the impacts resulting from construction and operation of the long-term storage facility for the 25% and 50% parametric cases would be roughly linear for throughput ranges of between 25% and 100%. Minimal to moderate, but temporary, waste management impacts would result from construction wastes. Negligible impacts would be associated with all waste forms generated during operations. Overall, the waste input resulting from storage facilities would have negligible impact on waste management capacities locally or across the DOE complex.

K.3.8 Resource Requirements

The estimated impacts from resource requirements during construction and operation of full-scale (100%) long-term storage facilities for UF_6 and oxide are presented in detail in Appendix G, Section G.3.8. The impacts on resources would be expected to be small for the 100% capacity storage case for all options. Resource requirements for the two parametric cases considered would be less than those for the 100% case (LLNL 1997a). In general, the amounts of construction materials would be roughly proportional to the storage capacity because the majority of the construction materials would be for the actual storage buildings and the number of storage buildings required would be linearly related to the required storage capacity.

Construction and operation of the proposed storage facilities would consume irretrievable amounts of electricity, fuel, concrete, steel and other metals, water, and miscellaneous chemicals. The total quantities of commonly used materials would not be expected to be significant. No strategic and critical materials (e.g., Monel or Inconel) in significant quantities are projected to be consumed during construction or operation for all long-term storage options. The storage options are not considered resource-intensive, and the resources required are generally not considered rare or unique. Furthermore, committing any of these resources would not be expected to cause a negative impact on the availability of these resources within local areas or nationally for the 100%, 50%, and 25% cases.

K.3.9 Land Use

Impacts to land use from the construction and operation of UF_6 storage buildings would be limited to the clearing of required land, potential minor and temporary disruptions to contiguous land parcels, and a slight increase in vehicular traffic. Site preparation for construction of a facility to store 25%, 50%, and 100% of the depleted UF_6 inventory in buildings would require the disturbance of approximately 42, 72, and 131 acres (17, 29, and 53 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 16, 30, and 62 acres (6.5, 12, and 25 ha) with structures and paved areas. The amount of land required for the other UF_6 storage options would be generally similar.

Land for storage buildings would be cleared incrementally over the projected 20-year construction project, thereby reducing the potential for land disturbance and consequential land disruption impacts. Such potential impacts, however, would be greatest at 100% of throughput capacity. Also, the areal requirement of 131 acres (53 ha) for the 100% capacity case could result in land-use changes if an existing site with limited open space were chosen.

Road and rail access within a storage site would be designed to minimize on-site traffic conflicts. For off-site traffic, only temporary, minor impacts associated with construction vehicles would be expected.

Storage as UO_2 would be expected to generate only negligible impacts to land use and would result in a lower areal requirement and less land disturbance compared with storage as UF_6. Site preparation for the construction of a facility to store 25%, 50%, and 100% of the depleted UF_6 inventory as UO_2 in buildings would require the disturbance of approximately 37, 49, and 79 acres (15, 20, and 32 ha), respectively. Within this disturbed area, the facility would require the permanent replacement of approximately 13, 20, and 35 acres (5.1, 8.1, and 14 ha) with structures and paved areas. The amount of land required for the other uranium oxide storage options would be generally similar.

Land for storage buildings would be cleared incrementally over the projected 20-year construction project, thereby reducing the potential for land disturbance and consequential land disruption impacts. Such potential impacts, however, would be greatest at 100% of throughput capacity. The peak labor force during the 20-year construction period, regardless of throughput capacity, would not be large enough to generate other than negligible off-site traffic impacts.

K.3.10 Other Impacts Considered But Not Analyzed in Detail

Other impacts could potentially occur if the long-term storage options considered in this PEIS were implemented — including impacts to cultural resources and environmental justice, as well as to aesthetics (e.g., visual environment), recreational resources, and noise levels, and impacts associated with decontamination and decommissioning of storage facilities. These impacts, although considered, were not analyzed in detail for one or both of the following reasons:

- The impacts could not be determined at the programmatic level without consideration of specific sites. These impacts would be more appropriately addressed in the second-tier NEPA documentation when specific sites are considered.
- Consideration of the impacts would not contribute to differentiation among the alternatives; therefore, it would not affect the decisions to be made in the Record of Decision that will be issued following publication of this PEIS.

K.4 MANUFACTURE AND USE OPTIONS

The parametric analysis of the manufacture and use options considered the environmental impacts of using 25% and 50% of the depleted UF_6 inventory in the form of either uranium metal or dense UO_2 to manufacture uranium-shielded casks. The analysis of both options (uranium metal or dense UO_2) was based on the assumption that depleted uranium would be used as the primary shielding material in containers, called “casks,” used to store spent nuclear fuel. The assessment considered the environmental impacts that would occur during (1) construction of a cask manufacturing facility, (2) routine operation of the cask manufacturing facility, and (3) potential manufacturing plant accidents. The manufacturing of casks was assumed to take place over a 20-year period, from 2009 through 2028. Impacts during use of depleted uranium shielded casks were not estimated in the PEIS.

The areas of impact and the methodologies used to evaluate the parametric cases for the manufacture and use options were the same as those used to evaluate the 100% cases. The evaluation of the 100% cases is presented in detail in Appendix H. The supporting engineering data for the 25% and 50% parametric cases are provided in the engineering analysis report (LLNL 1997a).

K.4.1 Human Health — Normal Operations

K.4.1.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from normal operation of a full-scale (100%) UO_2 cask manufacturing facility are described in Appendix H, Section H.3.1.1. Similar impacts were calculated for the manufacture of casks using 50% and 25% of the depleted UF_6 inventory. The radiological impacts estimated for the 100%, 50%, and 25% case are shown in Figures K.37 through K.42 as radiation doses to each of the six receptor scenarios considered in the PEIS: members of the general public — annual collective dose and annual dose to the MEI; noninvolved workers — annual collective dose and annual dose to the MEI; and involved workers — annual collective dose and annual average individual dose. Because the radiological impacts to involved workers (Figures K.41 and K.42) would not depend on the location of the manufacturing facility, no ranges of impact are presented. Ranges of impacts are presented for noninvolved workers and the general public in Figures K.37 through K.40. The range of impacts for noninvolved workers would be related only to possible differences in site meteorological conditions. The impact range for members of the general public would be related to differences in both meteorological conditions and population density (i.e., from rural to urban areas).

The results of the parametric analysis (as shown in Figures K.37 through K.42) indicate that the collective radiological impacts would scale relatively linearly with the total quantity of depleted UF_6 used to manufacture the casks. The impacts of the 25% and 50% cases would be smaller than those for the 100% case, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than half of the impacts for the 100% case). The doses shown in the figures can be converted to the number (or risk) of LCFs by multiplying the doses (in rem or person-rem) by 0.0005 LCF/person-rem for members of the public and 0.0004 LCF/person-rem for workers. Additional discussion of the significance of the estimated doses is provided in Appendix H, Section H.3.1.1.

The estimated radiation doses from the manufacture of uranium metal casks for the 100%, 50%, and 25% throughput cases are presented in Figures K.43 through K.48. The general relationship between radiological impacts and throughput would be similar to that for UO_2 casks; that is, the radiological impacts would decrease with decreasing throughput, although at a rate not proportional to the reduction in throughput.

K.4.1.2 Chemical Impacts

The estimated impacts from chemical exposures during the normal operation of full-scale (100%) cask manufacturing facilities for UO_2 and uranium metal are described in Appendix H, Section H.3.1.2. The results of the 100% case analyses indicated that noninvolved workers and members of the general public would receive very low exposures to chemicals from the normal

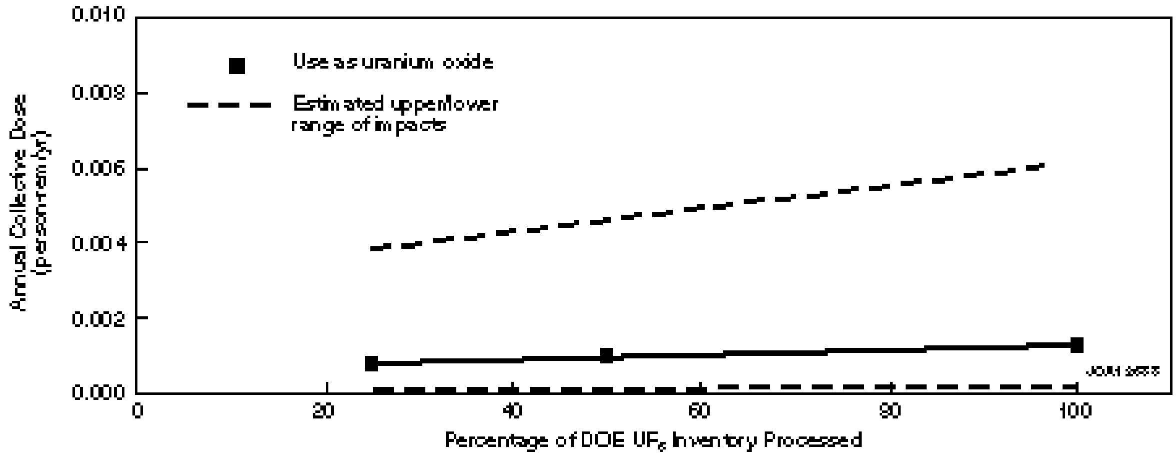

FIGURE K.37 Estimated Annual Collective Dose to Members of the Public from the Manufacture of Casks Using UO_2 (The upper and lower ranges reflect differences in site characteristics, such as meteorological conditions and rural or urban area.)

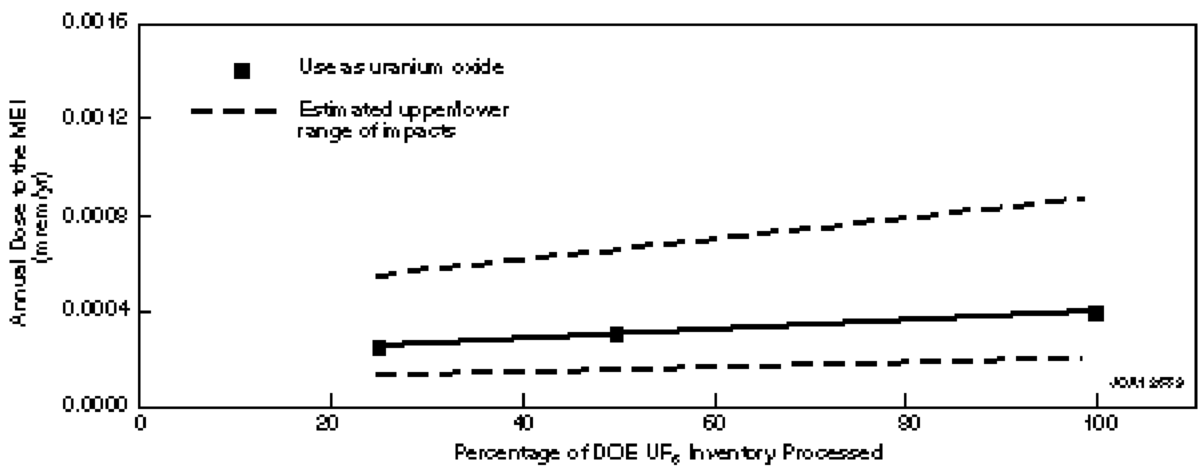

FIGURE K.38 Estimated Annual Dose to the General Public MEI from the Manufacture of Casks Using UO_2 (The upper and lower ranges reflect differences between site characteristics, primarily meteorological conditions.)

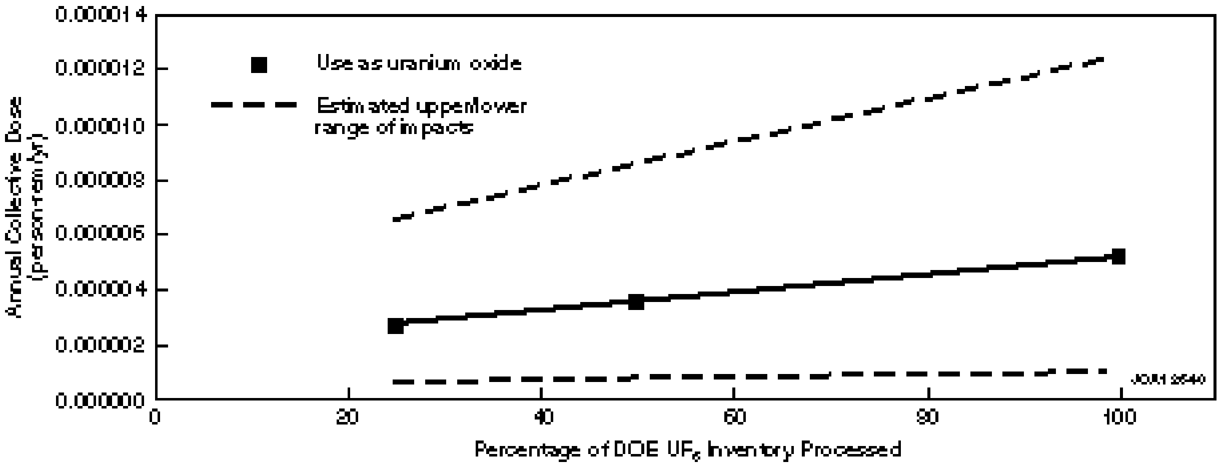

FIGURE K.39 Estimated Annual Collective Dose to Noninvolved Workers from the Manufacture of Casks Using UO_2 (The upper and lower ranges reflect differences in site characteristics, primarily meteorological conditions.)

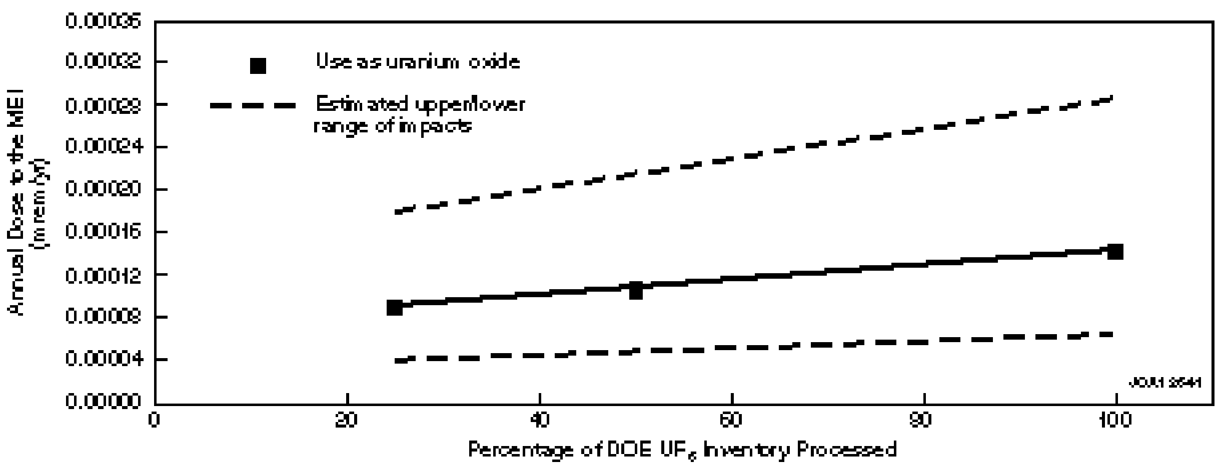

FIGURE K.40 Estimated Annual Dose to the Noninvolved Worker MEI from the Manufacture of Casks Using UO_2 (The upper and lower ranges reflect differences in site characteristics, primarily meteorological conditions.)

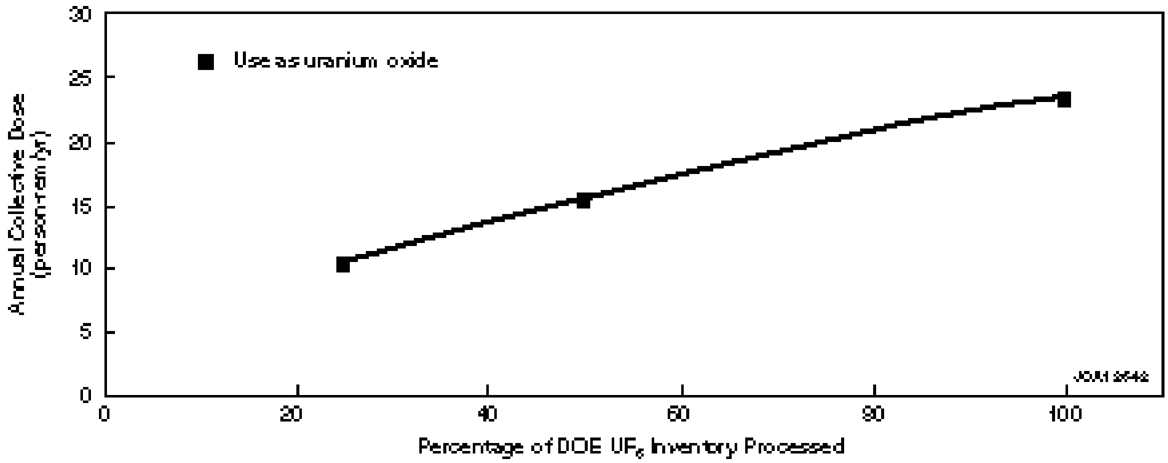

FIGURE K.41 Estimated Annual Collective Dose to Involved Workers from the Manufacture of Casks Using UO_2

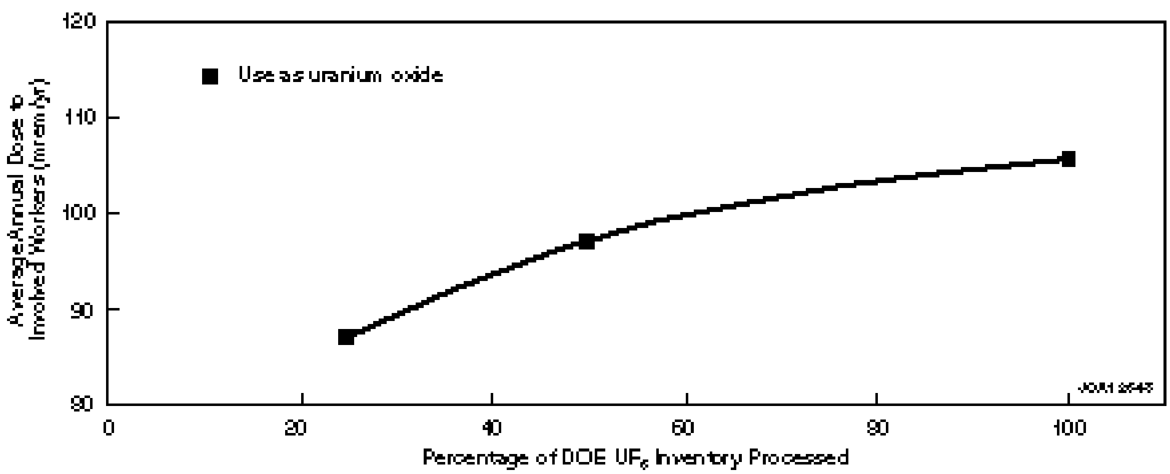

FIGURE K.42 Estimated Annual Average Individual Dose to Involved Workers from the Manufacture of Casks Using UO_2

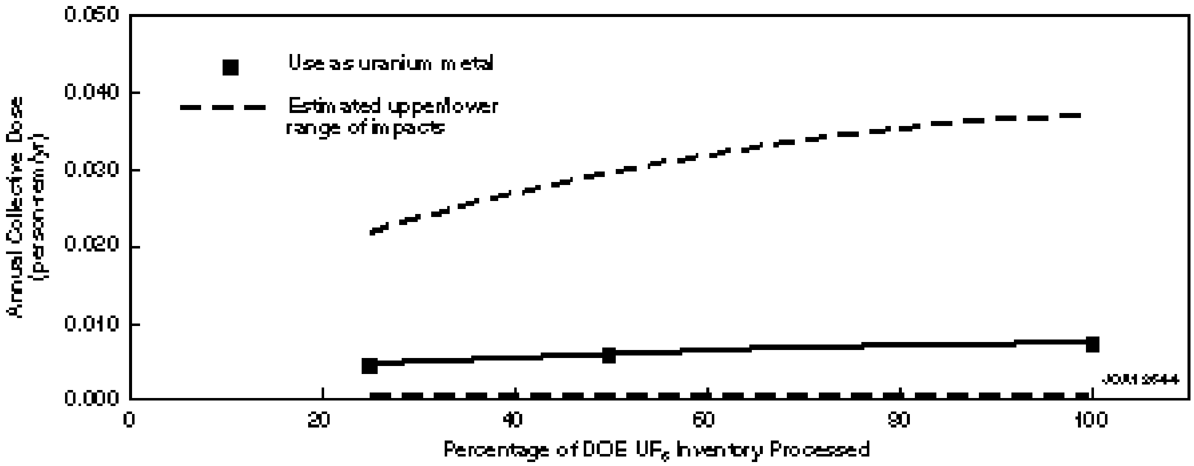

FIGURE K.43 Estimated Annual Collective Dose to Members of the Public from the Manufacture of Casks Using Uranium Metal (The upper and lower ranges reflect differences in site characteristics, such as meteorological conditions and rural or urban area.)

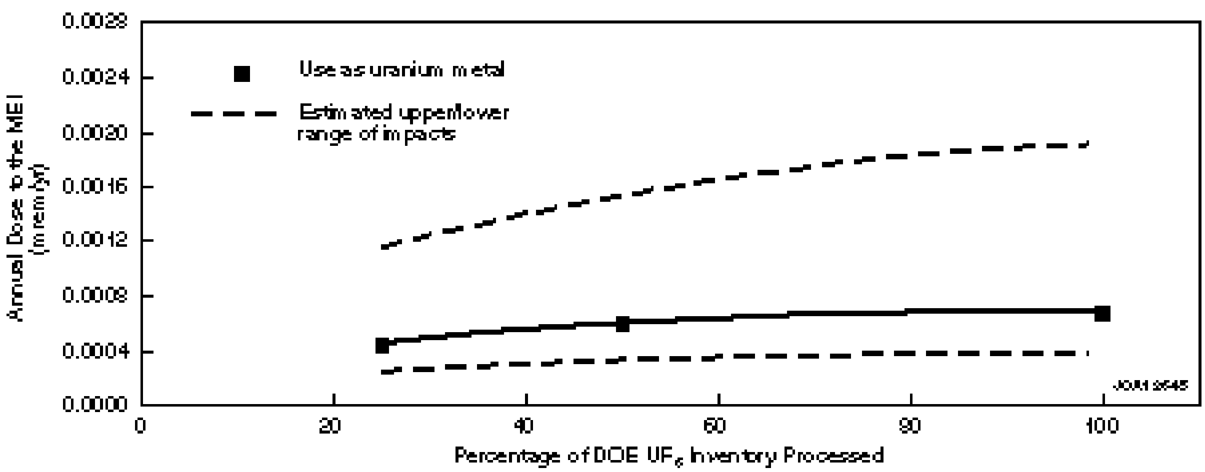

FIGURE K.44 Estimated Annual Dose to the General Public MEI from the Manufacture of Casks Using Uranium Metal (The upper and lower ranges reflect differences in site characteristics, primarily meteorological conditions.)

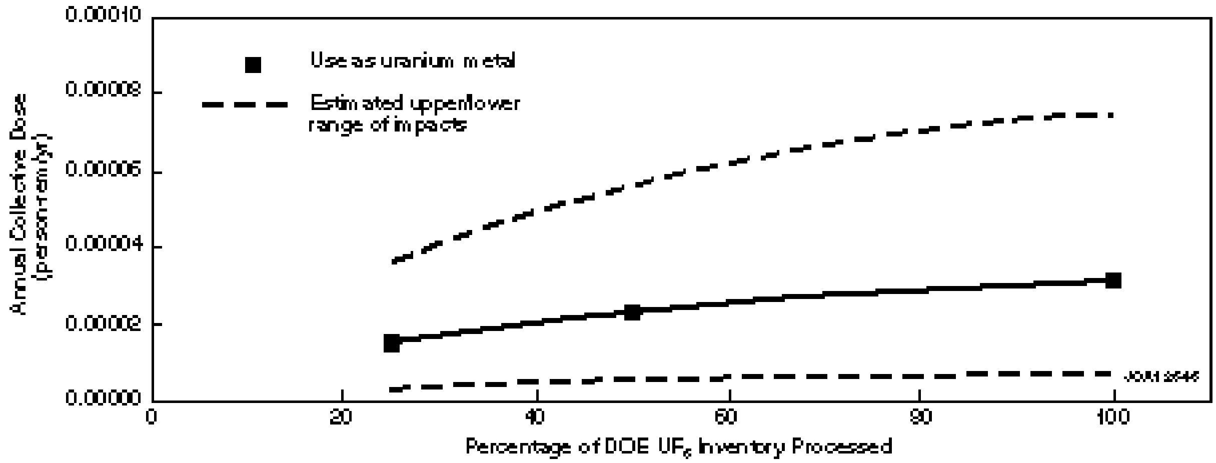

FIGURE K.45 Estimated Annual Collective Dose to Noninvolved Workers from the Manufacture of Casks Using Uranium Metal (The upper and lower ranges reflect differences in site characteristics, primarily meteorological conditions.)

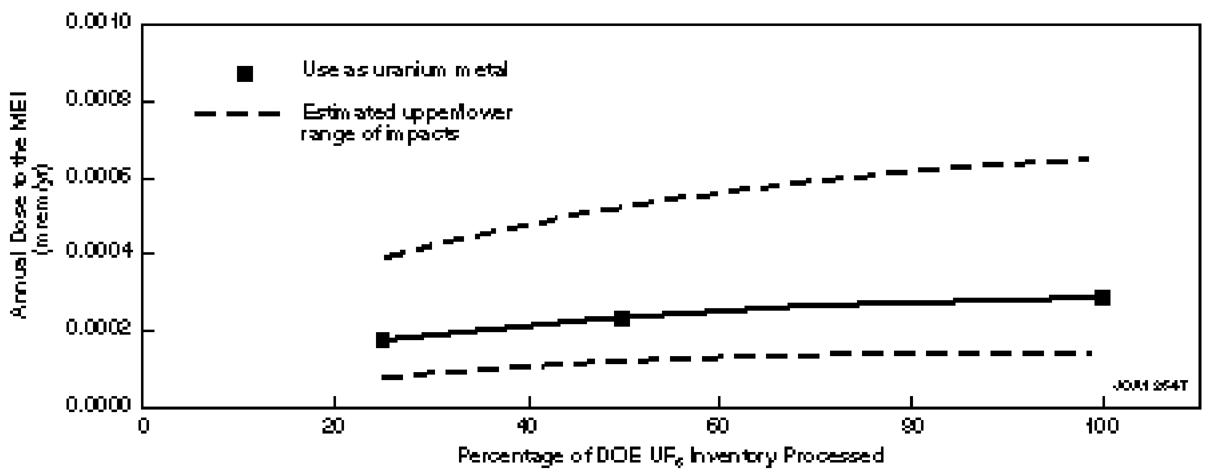

FIGURE K.46 Estimated Annual Dose to the Noninvolved Worker MEI from the Manufacture of Casks Using Uranium Metal (The upper and lower ranges reflect differences in site characteristics, primarily meteorological conditions.)

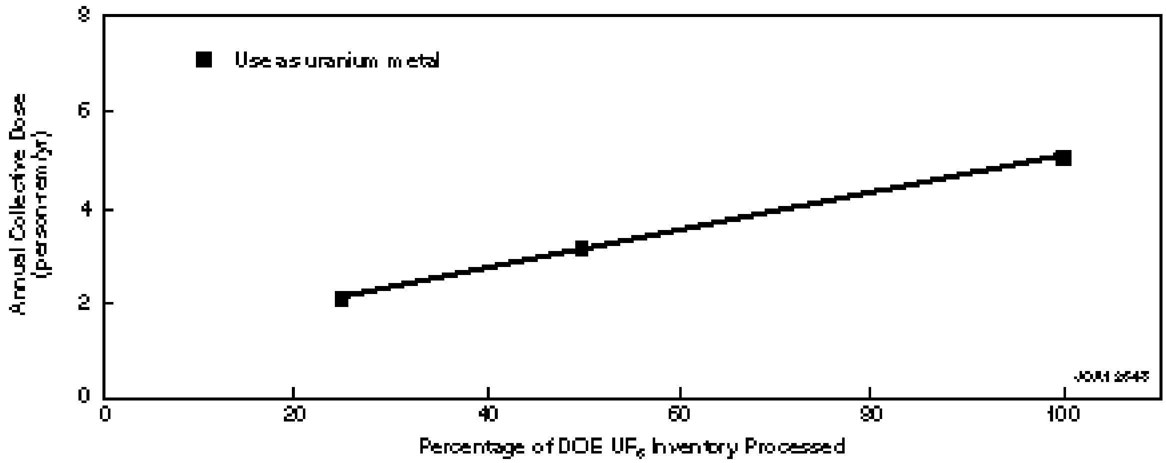

FIGURE K.47 Estimated Annual Collective Dose to Involved Workers from the Manufacture of Casks Using Uranium Metal

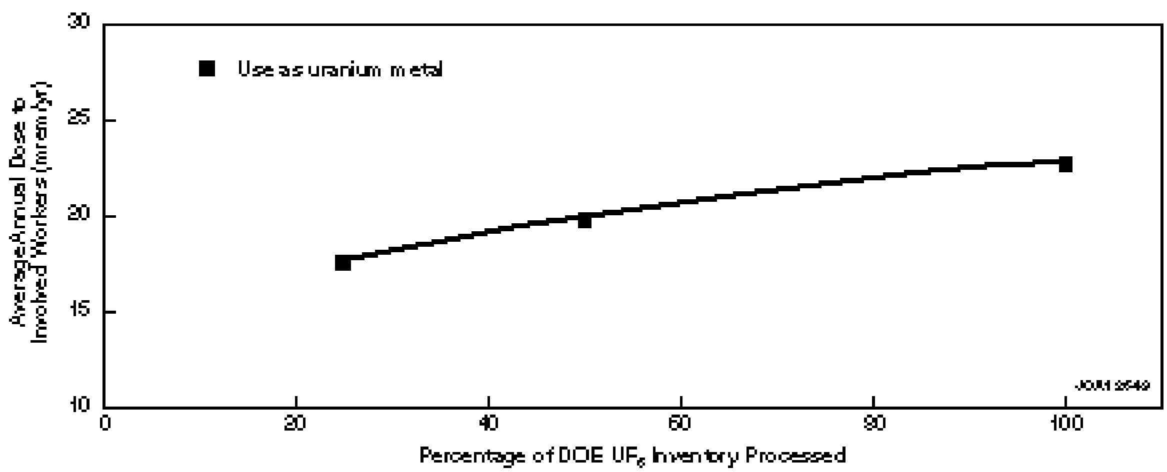

FIGURE K.48 Estimated Annual Average Individual Dose to Involved Workers from the Manufacture of Casks Using Uranium Metal

operation of manufacturing facilities and that no adverse health impacts would be expected. For the 100% cases, the calculated hazard indices were much less than 1 during normal operations (a hazard index of greater than 1 indicates the potential for health impacts). For the parametric analysis of the 25% and 50% throughput cases, airborne emissions during normal operations would be less than the 100% cases and extremely small (LLNL 1997a). Therefore, by comparison with the 100% case results, no adverse health impacts from chemical exposures would be expected for throughput rates between 25% and 100% for the manufacture of UO_2 and uranium metal shielded casks.

K.4.2 Human Health — Accident Conditions

K.4.2.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from potential accidents during the operation of full-scale (100%) cask manufacturing facilities are presented in Appendix H, Section H.3.2.1. The analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented only for those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

The impacts from bounding accidents for the 25% and 50% throughput cases would be the same as those presented in Appendix H, Section H.3.2.1 for the 100% case, with two exceptions. For the manufacture of both uranium oxide and uranium metal shielded casks, the bounding accident impacts for the “unlikely” frequency category would be less for the 25% and 50% cases than for the 100% case. The radiological impacts for these accident categories are presented in Tables K.3 and K.4 for the 100%, 50%, and 25% cases.

K.4.2.2 Chemical Impacts

The estimated chemical impacts from potential accidents during the operation of full-scale (100%) cask manufacturing facilities using uranium oxide and uranium metal are presented in Appendix H, Section H.3.2.2. The analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented only for those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

The bounding chemical accidents associated with the 25% and 50% throughput cases would be the same as those presented for the 100% cases in Appendix H. The impacts would be similar because the bounding accidents within most frequency categories would be the same as

TABLE K.3 Estimated Radiological Doses per Accident Occurrence for the Manufacture and Use Options

			Maximum Dose[c]				Minimum Dose[c]			
			Noninvolved Workers		General Public		Noninvolved Workers		General Public	
Option/ Accident[a]	Frequency Category[b]	Capacity (%)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)
Use as Uranium Oxide Casks										
Earthquake	Unlikely	100	7.7×10^{-2}	2.9×10^{-2}	2.3×10^{-3}	3.2×10^{-1}	3.2×10^{-3}	1.2×10^{-3}	9.2×10^{-5}	1.1×10^{-3}
		50	3.9×10^{-2}	1.5×10^{-2}	1.1×10^{-3}	1.6×10^{-1}	1.6×10^{-3}	6.1×10^{-4}	4.6×10^{-5}	5.4×10^{-4}
		25	1.9×10^{-2}	7.3×10^{-3}	5.7×10^{-4}	7.9×10^{-2}	8.1×10^{-4}	3.0×10^{-4}	2.3×10^{-5}	2.7×10^{-4}
Use as Uranium Metal Casks										
Earthquake	Unlikely	100	1.1×10^{-2}	4.3×10^{-3}	3.4×10^{-4}	4.6×10^{-2}	4.7×10^{-4}	1.8×10^{-4}	1.3×10^{-5}	1.6×10^{-4}
		50	5.5×10^{-3}	2.2×10^{-3}	1.7×10^{-4}	2.3×10^{-2}	2.3×10^{-4}	9.0×10^{-5}	6.5×10^{-6}	8.0×10^{-5}
		25	2.8×10^{-3}	1.1×10^{-3}	8.5×10^{-5}	1.2×10^{-2}	1.2×10^{-4}	4.5×10^{-5}	3.3×10^{-6}	4.0×10^{-5}

[a] The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[b] An unlikely accident is estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} – 10^{-4}$/yr).

[c] Maximum and minimum doses reflect differences in assumed sites, technologies, and meteorological conditions at the time of the accident. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed.

TABLE K.4 Estimated Radiological Health Risks per Accident Occurrence for the Manufacture and Use Options

			Maximum Risk[c] (LCFs)				Minimum Risk[c] (LCFs)			
			Noninvolved Workers		General Public		Noninvolved Workers		General Public	
Option/ Accident[a]	Frequency Category[b]	Capacity (%)	MEI	Population	MEI	Population	MEI	Population	MEI	Population
Use as Uranium Oxide Casks										
Earthquake	Unlikely	100	3×10^{-5}	1×10^{-5}	1×10^{-6}	2×10^{-4}	1×10^{-6}	5×10^{-7}	5×10^{-8}	5×10^{-7}
		50	2×10^{-5}	6×10^{-6}	6×10^{-7}	8×10^{-5}	6×10^{-7}	2×10^{-7}	2×10^{-8}	3×10^{-7}
		25	8×10^{-6}	3×10^{-6}	3×10^{-7}	4×10^{-5}	3×10^{-7}	1×10^{-7}	1×10^{-8}	1×10^{-7}
Use as Uranium Metal Casks										
Earthquake	Unlikely	100	4×10^{-6}	2×10^{-6}	2×10^{-7}	2×10^{-5}	2×10^{-7}	7×10^{-8}	7×10^{-9}	8×10^{-8}
		50	2×10^{-6}	9×10^{-7}	8×10^{-8}	1×10^{-5}	1×10^{-7}	4×10^{-8}	3×10^{-9}	4×10^{-8}
		25	1×10^{-6}	4×10^{-7}	4×10^{-8}	6×10^{-6}	5×10^{-8}	2×10^{-8}	2×10^{-9}	2×10^{-8}

[a] The accident chosen to represent each frequency category is the one that would result in the highest risk to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[b] An unlikely accident is estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} – 10^{-4}$/yr).

[c] Maximum and minimum doses reflect differences in assumed sites, technologies, and meteorological conditions at the time of the accident. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed.

the 100%, 50%, and 25% cases, and in those cases where these accidents were different, no adverse chemical impacts were estimated to occur. The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. Some of the impacts from other accidents considered for the 25% and 50% cases (nonbounding) would be different from those for the 100% cases. In general, the impacts of these nonbounding accidents for the 50% and 25% cases would be less than those for the 100% cases because of the reduced throughput.

K.4.2.3 Physical Hazards

The estimated health impacts, such as on-the-job injuries and fatalities, from potential physical accidents during the construction and operation of full-scale (100%) cask manufacturing facilities are presented in Appendix H, Section H.3.2.3. For the 100% analysis, up to 1 on-the-job fatality was predicted for the manufacture of both uranium oxide and uranium metal shielded casks. The predicted number of on-the-job worker injuries for the 100% case was 640 for manufacturing uranium oxide shielded casks and 670 for uranium metal shielded casks. For the two options analyzed in detail in the parametric analysis, the impacts of the 25% and 50% cases would be smaller than those for the 100% cases, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than 50% of the impacts for the 100% case).

The predicted number of on-the-job worker fatalities over the entire 20 years of the manufacture of uranium oxide or uranium metal shielded casks is about 1 (including construction and operations). For uranium oxide shielded casks, the number would range from 0.6 for the 25% case to 0.76 for the 100% case; whereas for uranium metal shielded casks, the number would range from 0.7 for the 25% case to 0.85 for the 100% case. The predicted number of on-the-job injuries (including construction and operations) would range from 480 to 640 for uranium oxide casks and from 510 to 670 for uranium metal casks. The estimated numbers of fatalities and injuries for uranium oxide and uranium metal shielded casks are shown as a function of throughput in Figures K.49 and K.50, respectively.

K.4.3 Air Quality

The estimated impacts on air quality during construction and operation of full-scale (100%) cask manufacturing facilities are presented in detail in Appendix H, Section H.3.3. All of the pollutant concentrations produced by the 100% capacity version of the storage facilities would be below their respective air quality standards. During construction, the largest impacts relative to air quality standards would occur for nitrogen oxides (NO_x). During construction, all pollutant concentrations would be less than 10% of the corresponding standards. During operations, all pollutant concentrations would also be less than 10% of the standards.

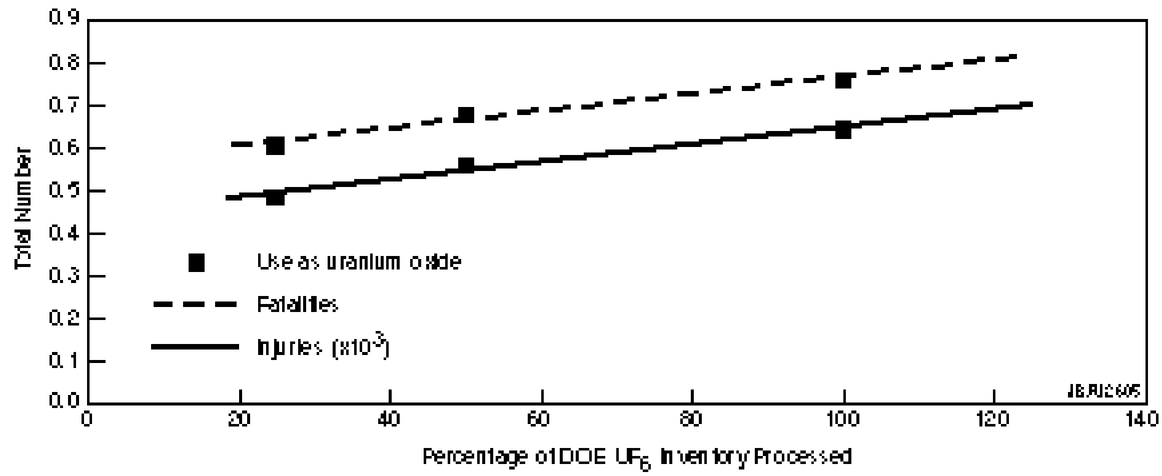

FIGURE K.49 Estimated Number of On-the-Job Fatalities and Injuries (for entire construction and operational periods) from the Manufacture of Uranium Oxide Shielded Casks

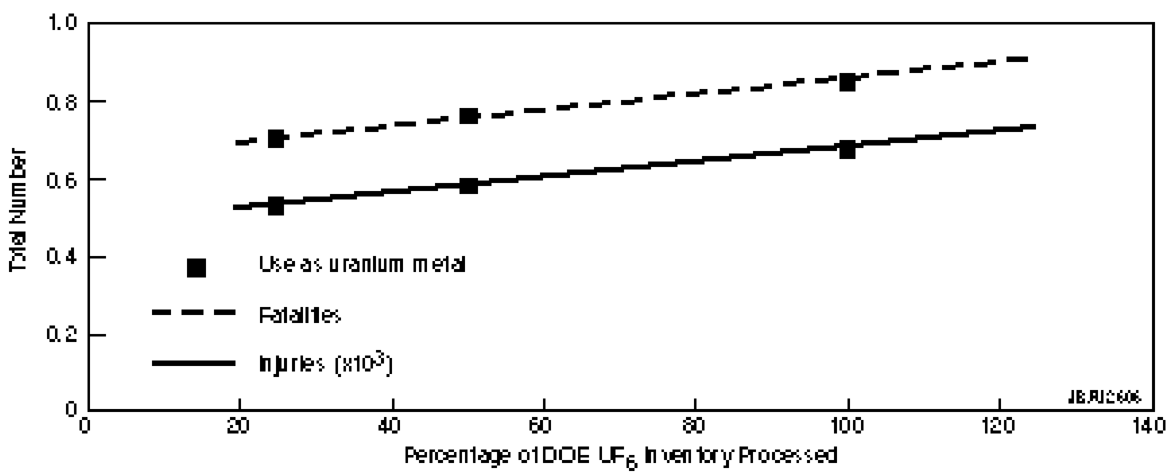

FIGURE K.50 Estimated Number of On-the-Job Fatalities and Injuries (for entire construction and operational periods) from the Manufacture of Uranium Metal Shielded Casks

The air quality impacts calculated for the 25% and 50% parametric cases, based on the information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases. During construction, short-term impacts for the parametric cases would be less than those for the 100% cases, and impacts during operations would also be less. The 25% case impacts would not be much smaller than the 50% case impacts, and the operations impacts in all cases would be less than 10% of the corresponding construction impacts.

K.4.4 Water and Soil

K.4.4.1 Surface Water

The estimated impacts on surface water during construction, operation, and potential accidents for full-scale (100%) cask manufacturing facilities are presented in detail in Appendix H, Section H.3.4. The potential impacts evaluated included changes in runoff, changes in quality, and floodplain encroachment. The impacts to surface water from the 100% cases were found to be negligible for manufacturing both uranium oxide and uranium metal shielded casks. The impacts estimated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.4.4.2 Groundwater

The estimated impacts on groundwater during construction, operation, and potential accidents for full-scale (100%) cask manufacturing facilities are presented in detail in Appendix H, Section H.3.4. The potential impacts evaluated included changes in the depth to groundwater, the direction of groundwater flow, recharge, and quality. The impacts to groundwater from the 100% cases were found to be negligible for manufacturing both uranium oxide and uranium metal shielded casks. The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.4.4.3 Soil

The estimated impacts to soil during construction, operation, and potential accidents for full-scale (100%) cask manufacturing facilities are presented in detail in Appendix H, Section H.3.4. The potential impacts evaluated included changes in topography, permeability, quality, and erosion potential. The impacts to soil from the 100% cases were found to be negligible for manufacturing both uranium oxide and uranium metal shielded casks. The impacts calculated for the 25% and 50%

parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% cases, and thus would also be negligible.

K.4.5 Socioeconomics

The socioeconomic impacts of UO_2 and metal manufacturing facilities for the 25% and 50% parametric cases would be less than the impacts of the base-case facility sizes. Cost information was not available in sufficient detail to allow an analysis of impacts using the same methodology that was used for the base cases. The impacts of parametric cases were therefore assessed qualitatively, based on the assumption that changes in the cost of equipment, materials, and labor would be proportional to changes in total life-cycle cost. Compared with base-case facility sizes, smaller UO_2 and metal manufacturing facilities would create less direct employment and income at the site.

K.4.6 Ecology

For both uranium oxide and uranium metal shielded cask manufacturing facilities, impacts to air quality, surface water, groundwater, and soil during construction and operations would be expected to be well below levels harmful to biota for the 25%, 50%, and 100% cases. Resulting contaminant-derived impacts to ecological resources would be expected to be negligible. Potential impacts to wetlands and state and federally protected species due to facility construction would depend on facility location. Avoidance of wetland areas would be included during facility planning. Site-specific surveys for protected species would be conducted prior to finalization of facility siting plans.

Site preparation for the construction of cask manufacturing facilities would result in the disturbance of biotic communities, including the permanent replacement of habitat with structures and paved areas (see Section K.4.9). Existing vegetation would be destroyed during land-clearing activities. Wildlife would be disturbed by land clearing, noise, and human presence. Depending on the exact location of the uranium oxide or uranium metal cask manufacturing facility, the loss of 27 to 90 acres (11 to 36 ha) of undeveloped land and habitat might constitute a moderate impact to vegetation and wildlife. However, when the uranium oxide and uranium metal cask manufacturing facilities were sited, all appropriate measures would be taken to preclude or minimize such impacts to ecological resources.

K.4.7 Waste Management

The estimated impacts from waste management operations from the construction and operation of full-scale (100%) cask manufacturing facilities are presented in detail in Appendix H, Section H.3.7. The impacts on regional and national waste management operations from construction and operation of manufacturing facilities were found to be negligible for the 100% throughput case.

On the basis of information provided in the engineering analysis report (LLNL 1997a), the impacts resulting from construction and operation for the 25% and 50% parametric cases would be roughly linear for throughput ranges of between 25% and 100%. Minimal waste management impacts would result from wastes generated during either construction or operations. Overall, the waste input resulting from normal operations at the manufacturing facilities would have negligible impact on waste management capacities locally or across the DOE complex. No assumptions were made regarding the fate of the oxide- and metal-shielded casks after use.

K.4.8 Resource Requirements

The estimated impacts from resource requirements during construction and operation of full-scale (100%) cask manufacturing facilities are presented in detail in Appendix H, Section H.3.8. The impacts on resources would be expected to be small for the 100% capacity case. Resource requirements for the two parametric cases considered would be less than those for the 100% case (LLNL 1997a).

Construction and operation of the cask manufacturing facilities would consume irretrievable amounts of electricity, fuel, concrete, steel and other metals, water, and miscellaneous chemicals. The total quantities of commonly used materials would not be expected to be significant. No strategic and critical materials (e.g., Monel or Inconel) in significant quantities are projected to be consumed during construction or operation of the facilities. Although high-grade graphite would be required for the metal shielded cask (as a lining for the crucibles containing molten uranium), the amounts required would not be significant. The manufacturing facility requirements would not be resource-intensive, and the resources required are generally not considered rare or unique. Furthermore, committing any of these resources would not be expected to cause a negative impact on the availability of these resources within local areas or nationally for the 100%, 50%, and 25% cases.

K.4.9 Land Use

Impacts to land use from the construction and operation of a uranium oxide shielded cask manufacturing facility, regardless of throughput capacity case, would be potentially moderate but limited to temporary disruptions to contiguous land parcels and increases in vehicular traffic associated with construction activities. Site preparation for the construction of a uranium oxide shielded cask manufacturing facility for 25%, 50%, and 100% of the depleted UF_6 inventory would require approximately 79, 84, and 90 acres (32, 34, and 36 ha), respectively. Within this area, the facility would require the permanent replacement of approximately 27, 28, and 31 acres (11, 11, and 13 ha) with structures and paved areas. Off-site impacts could occur from peak-year construction force vehicles, especially if the site had limited access from existing roadways.

Impacts to land use from the uranium metal shielded cask manufacturing facility would be the same as those discussed for the construction and operation of a uranium oxide shielded cask manufacturing facility, with no difference in the magnitude of impacts when the three throughput capacity cases are compared. For off-site impacts, traffic patterns could experience potentially adverse level-of-service impacts during the 7-year construction period from the peak-year construction labor force.

K.4.10 Other Impacts Considered But Not Analyzed in Detail

Other impacts could potentially occur if the manufacture and use options considered in this PEIS were implemented — including impacts to cultural resources and environmental justice, as well as to aesthetics (e.g., visual environment), recreational resources, and noise levels, and impacts associated with decontamination and decommissioning of manufacturing facilities. These impacts, although considered, were not analyzed in detail for one or both of the following reasons:

- The impacts could not be determined at the programmatic level without consideration of specific sites. These impacts would be more appropriately addressed in the second-tier NEPA documentation when specific sites are considered.

- Consideration of the impacts would not contribute to differentiation among the alternatives; therefore, it would not affect the decisions to be made in the Record of Decision that will be issued following publication of this PEIS.

K.5 DISPOSAL OPTIONS

The parametric analysis of the disposal options considered the environmental impacts of disposing of 25% and 50% of the depleted UF_6 inventory as an oxide form. It was assumed that the uranium material would be actively placed into disposal units over a 20-year period (from 2009 through 2028). The assessment considered the environmental impacts that would occur during (1) construction of a disposal facility, (2) routine disposal facility operations, (3) potential disposal facility accidents, and (4) the post-closure phase, defined as 1,000 years in the future after the disposal facility had failed. The areas of impact and the methodologies used to evaluate the parametric cases were the same as those used to evaluate the 100% cases discussed in Appendix I. The supporting engineering data for the 25% and 50% parametric cases are provided in the engineering analysis report (LLNL 1997a).

The environmental impacts for the 100% disposal case are presented in Appendix I for (1) disposal of grouted and ungrouted U_3O_8 in shallow earthen structures, vaults, and a mine; and (2) disposal of grouted and ungrouted UO_2 in shallow earthen structures, vaults, and a mine. Two representative locations, described in Chapter 3 of the PEIS, were considered for each option: a "dry" location and a "wet" location. For purposes of the parametric analysis, disposal of ungrouted U_3O_8 in a mine at both wet and dry locations was considered in detail. This option was chosen to simplify the parametric analysis because all options were evaluated in detail for the 100% base case. Impacts for the other disposal options, such as disposal of UO_2 and disposal in shallow earthen structures and vaults, were inferred from the relationships among the options identified from the 100% case analysis and from the additional relationships identified by the detailed parametric analysis conducted for the disposal of grouted U_3O_8 in a mine.

K.5.1 Human Health — Normal Operations

K.5.1.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from the normal operation of a full-scale (100%) disposal facility are described in Appendix I, Section I.3.1.1. Similar impacts were calculated for the 50% and 25% disposal facilities for the parametric analysis. Radiological impacts were calculated for the operational phase, during which time material would be disposed of, and for the post-closure phase, assumed to be 1,000 years in the future after the disposal facility had failed.

K.5.1.1.1 Operational Phase

The radiological impacts estimated for the 100%, 50%, and 25% cases during the operational phase are shown in Figures K.51 through K.66 for all disposal options. The impacts have been presented for the disposal of both grouted and ungrouted U_3O_8 and UO_2 as a function of the amount of material requiring disposal. The disposal of ungrouted U_3O_8 or UO_2 would not result in any airborne or waterborne emissions during operations because the material would be delivered to the disposal facility in packages that would be disposed of without being opened. Therefore, for the disposal of ungrouted waste, no impacts would be expected to the noninvolved workers and the off-site general public. The range of impacts resulting from technology and site differences are presented by dashed lines in the figures. The results for the disposal of ungrouted U_3O_8 in a mine, the case selected for detailed analysis, are shown in Figures K.63 and K.64 as solid points, with a curve drawn between the points to indicate how the impacts would vary as a function of the percent of material requiring disposal. The area enclosed by the dashed lines in Figures K.51 through K.66 indicates the range of impacts expected for throughputs between 25% and 100%, taking into account both technology and site differences.

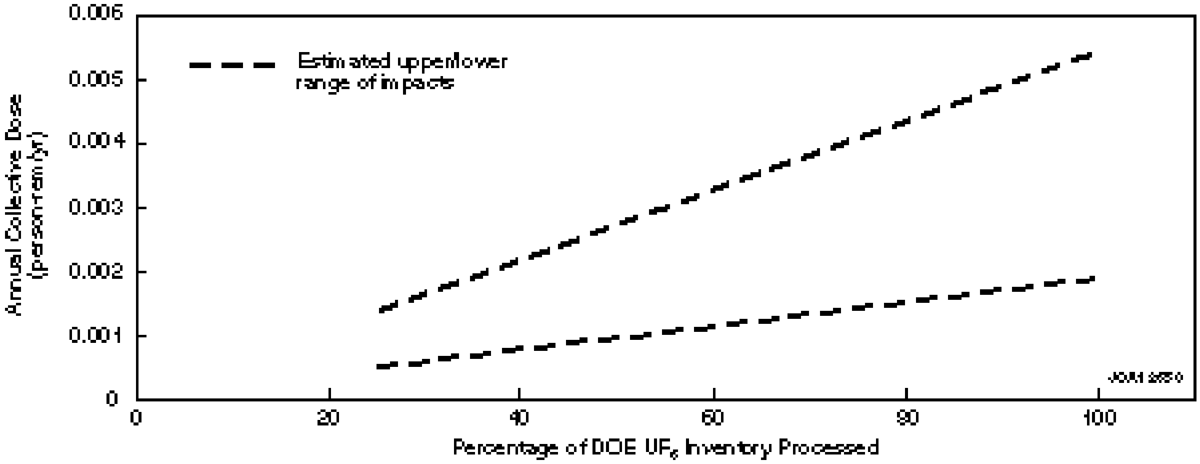

FIGURE K.51 Estimated Annual Collective Dose to Members of the Public from the Disposal of Grouted U_3O_8 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

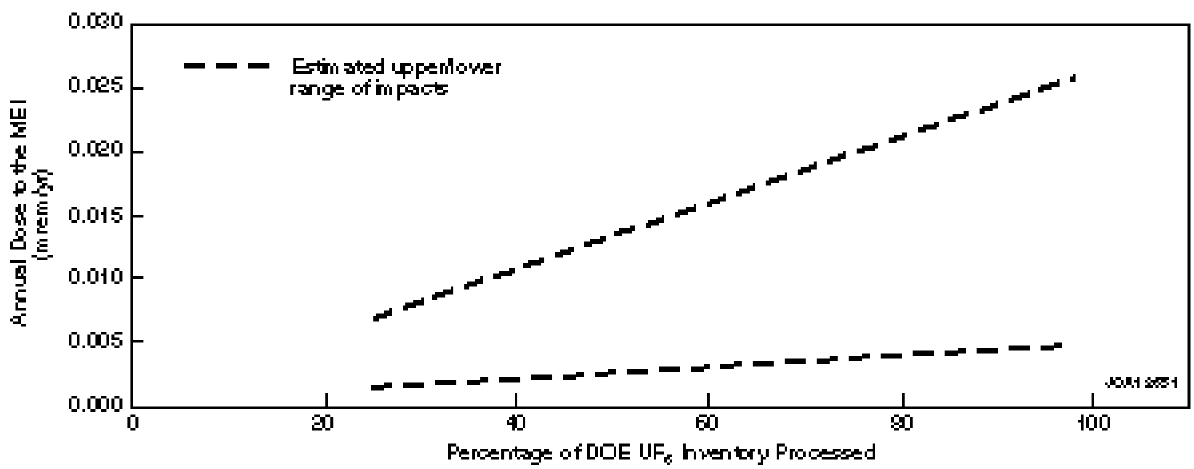

FIGURE K.52 Estimated Annual Dose to the General Public MEI from the Disposal of Grouted U_3O_8 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

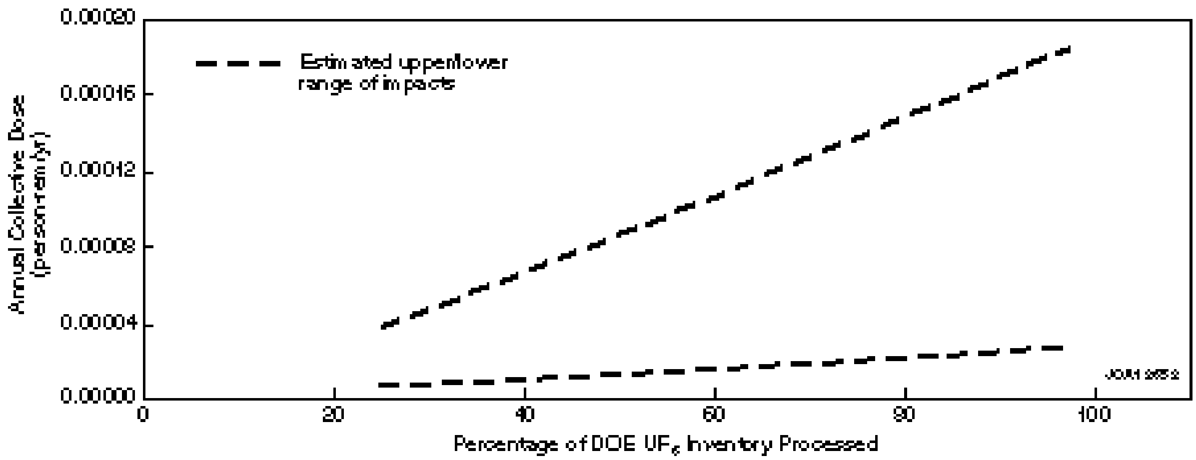

FIGURE K.53 Estimated Annual Collective Dose to Noninvolved Workers from the Disposal of Grouted U_3O_8 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

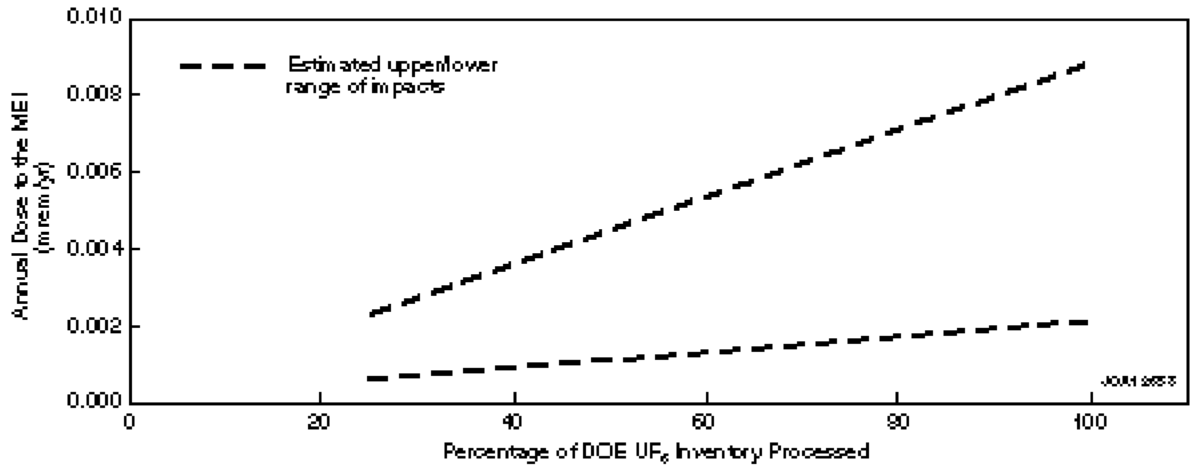

FIGURE K.54 Estimated Annual Dose to the Noninvolved Worker MEI from the Disposal of Grouted U_3O_8 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

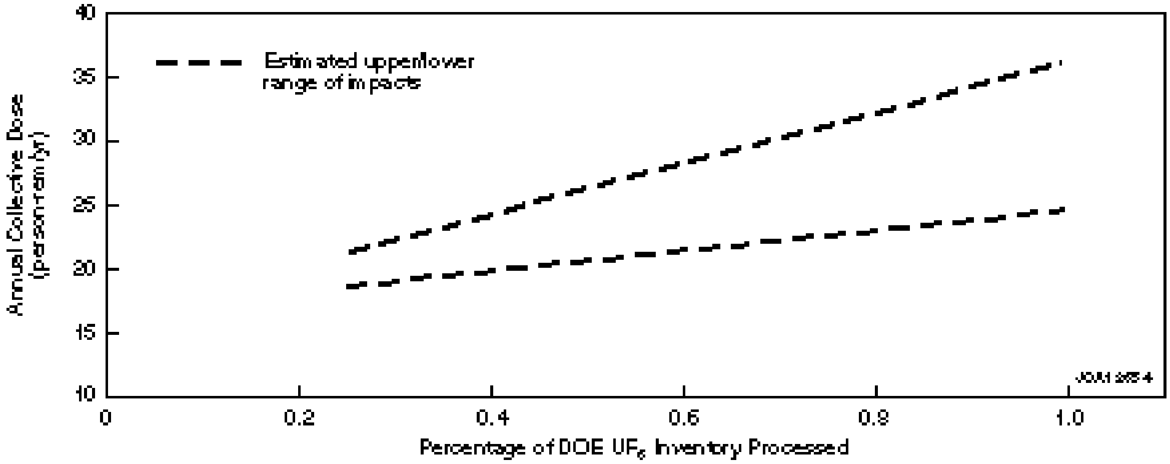

FIGURE K.55 Estimated Annual Collective Dose to Involved Workers from the Disposal of Grouted U_3O_8 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

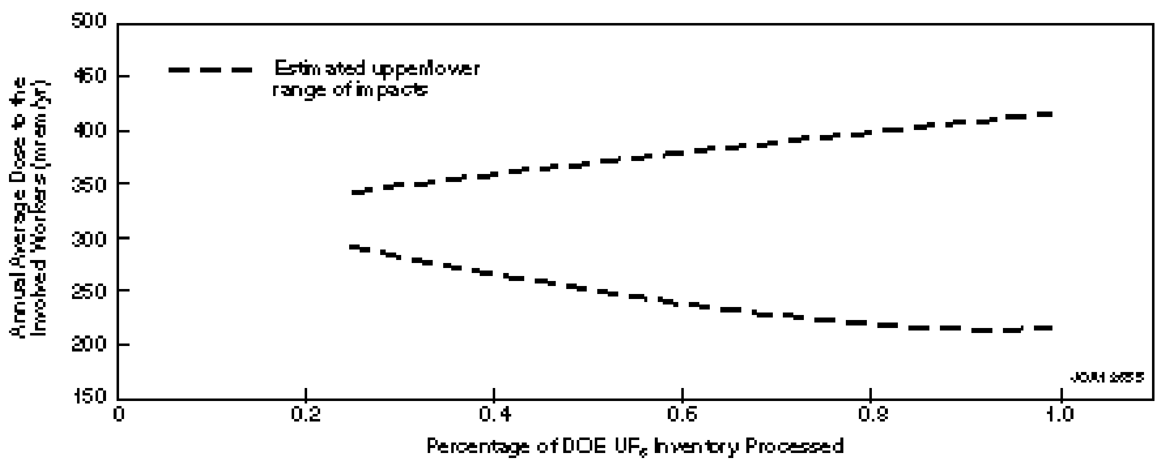

FIGURE K.56 Estimated Annual Average Individual Dose to Involved Workers from the Disposal of Grouted U_3O_8 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

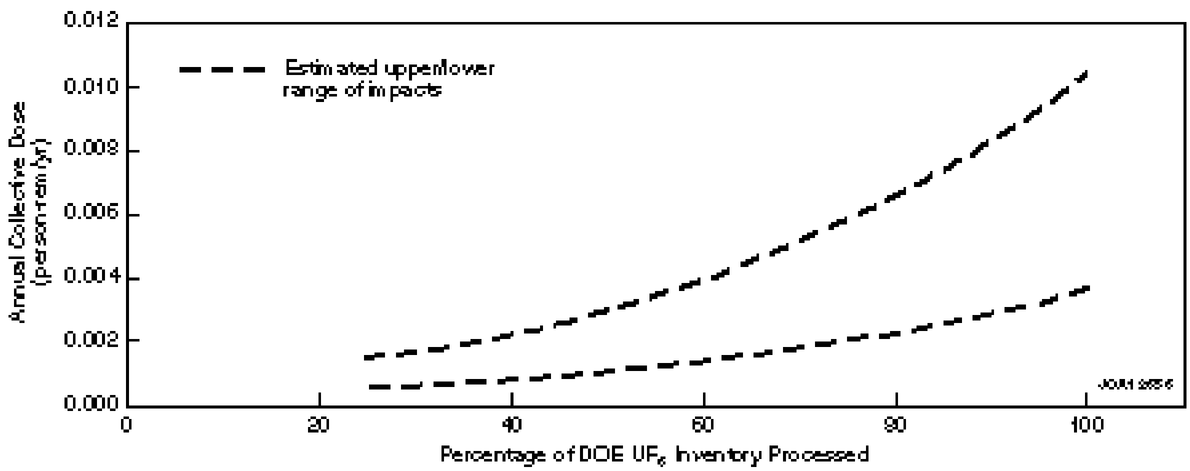

FIGURE K.57 Estimated Annual Collective Dose to Members of the Public from the Disposal of Grouted UO_2 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

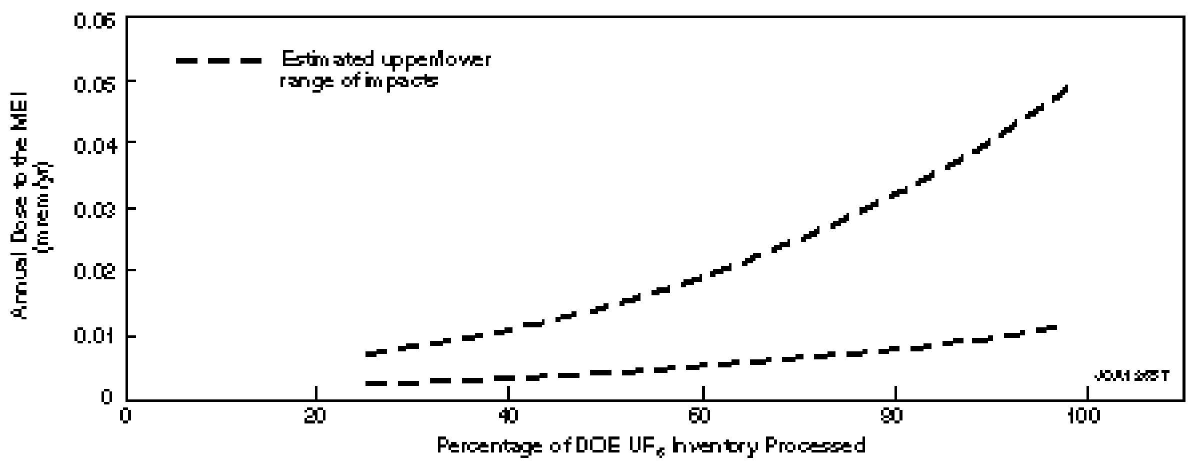

FIGURE K.58 Estimated Annual Dose to the General Public MEI from the Disposal of Grouted UO_2 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

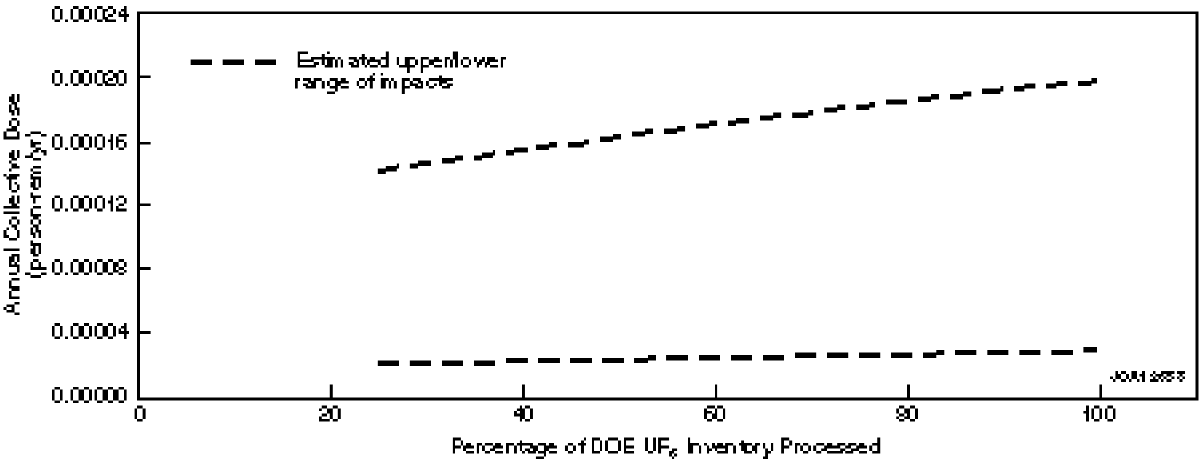

FIGURE K.59 Estimated Annual Collective Dose to Noninvolved Workers from the Disposal of Grouted UO_2 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

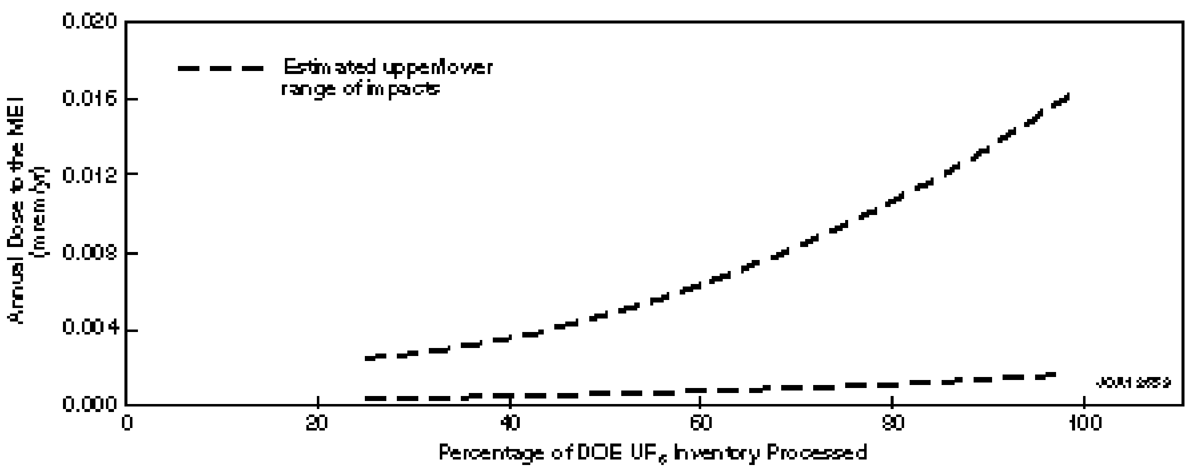

FIGURE K.60 Estimated Annual Dose to the Noninvolved Worker MEI from the Disposal of Grouted UO_2 (The upper and lower ranges reflect differences in representative dry and wet site characteristics.)

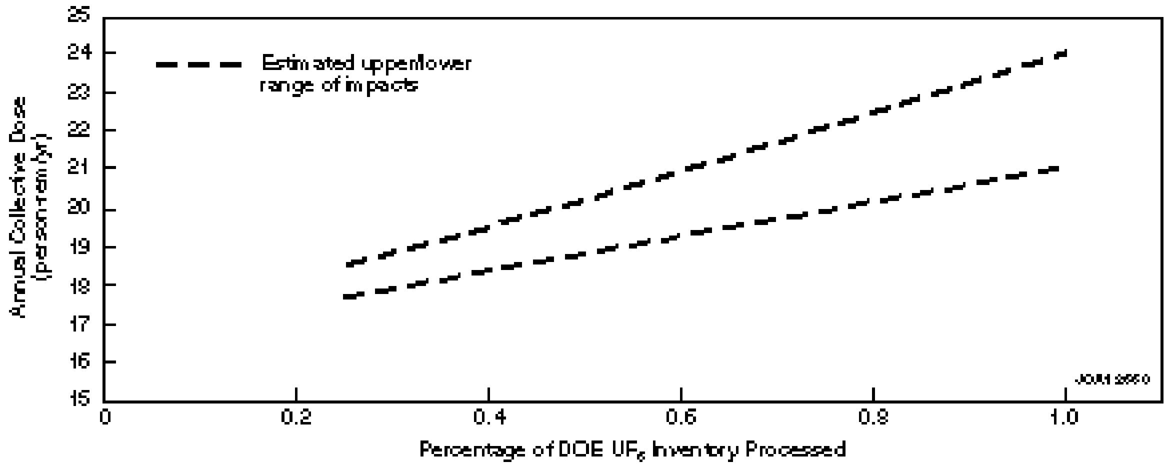

FIGURE K.61 Estimated Annual Collective Dose to Involved Workers from the Disposal of Grouted UO_2 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

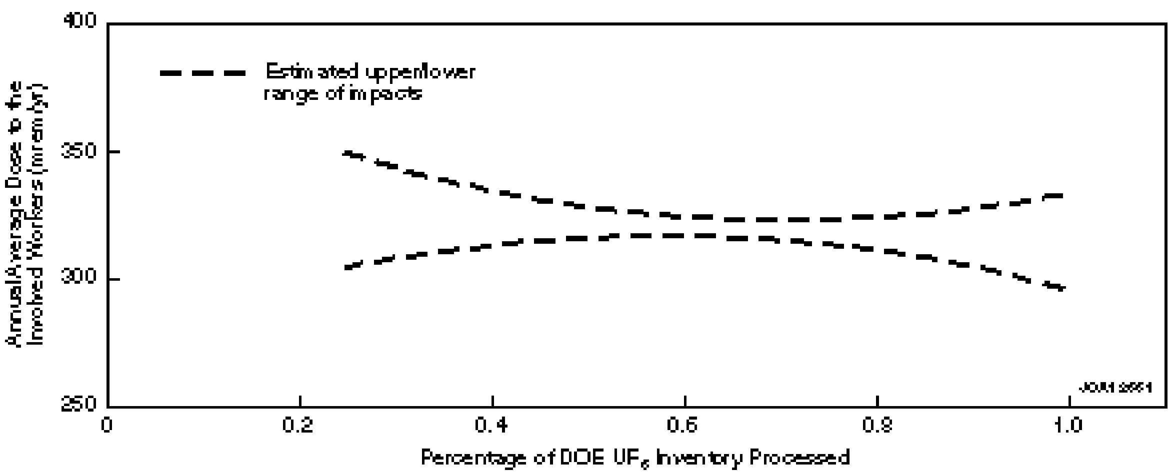

FIGURE K.62 Estimated Annual Average Individual Dose to Involved Workers from the Disposal of Grouted UO_2 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

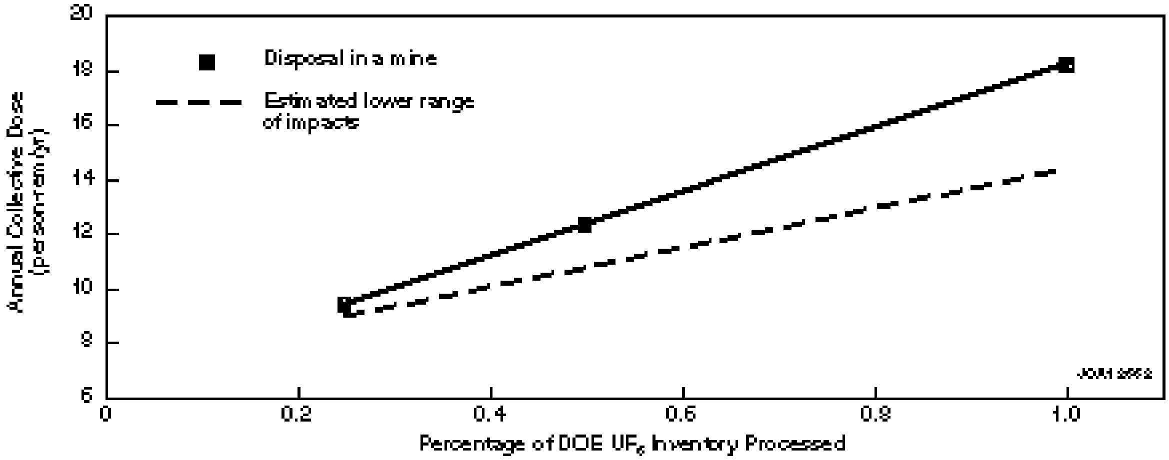

FIGURE K.63 Estimated Annual Collective Dose to Involved Workers from the Disposal of Ungrouted U_3O_8 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

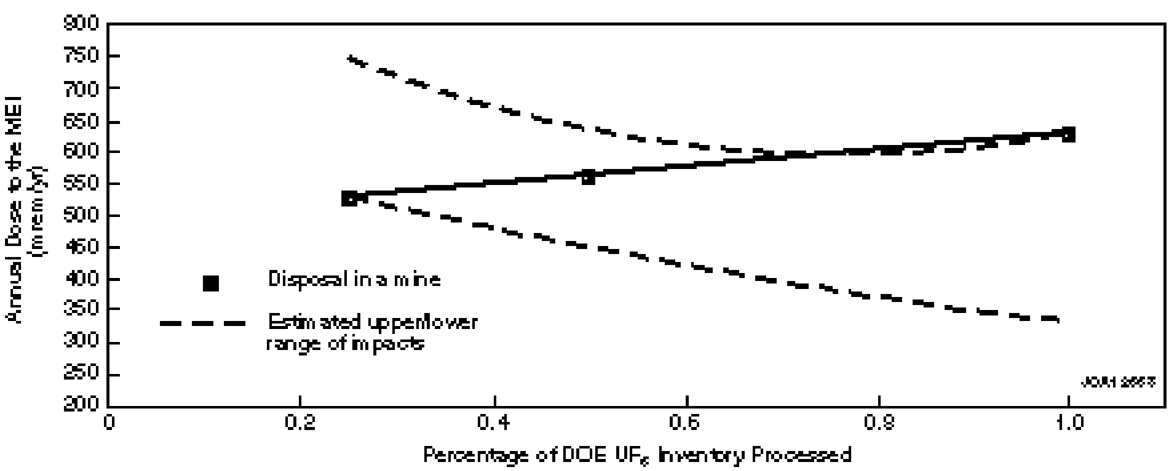

FIGURE K.64 Estimated Annual Average Individual Dose to Involved Workers from the Disposal of Ungrouted U_3O_8 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

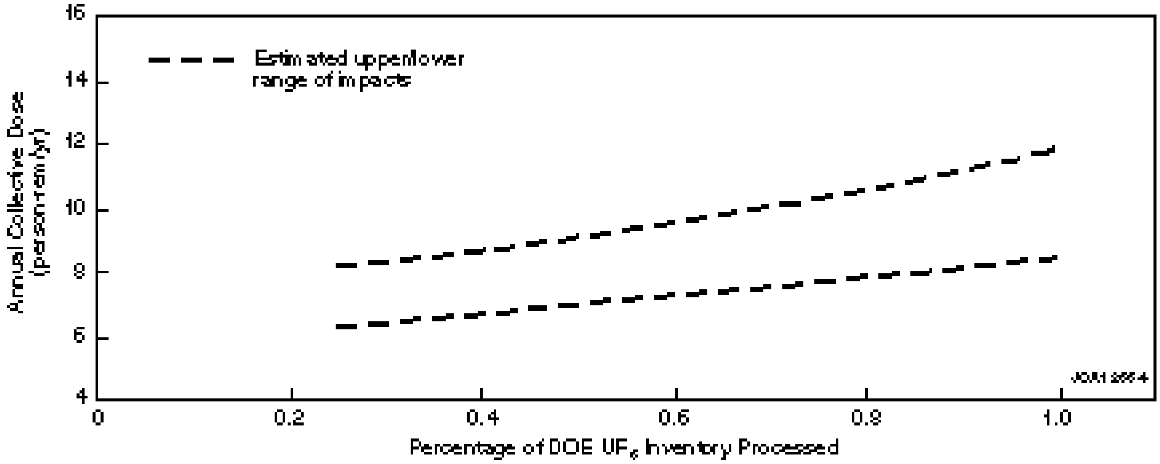

FIGURE K.65 Estimated Annual Collective Dose to Involved Workers from the Disposal of Ungrouted UO_2 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

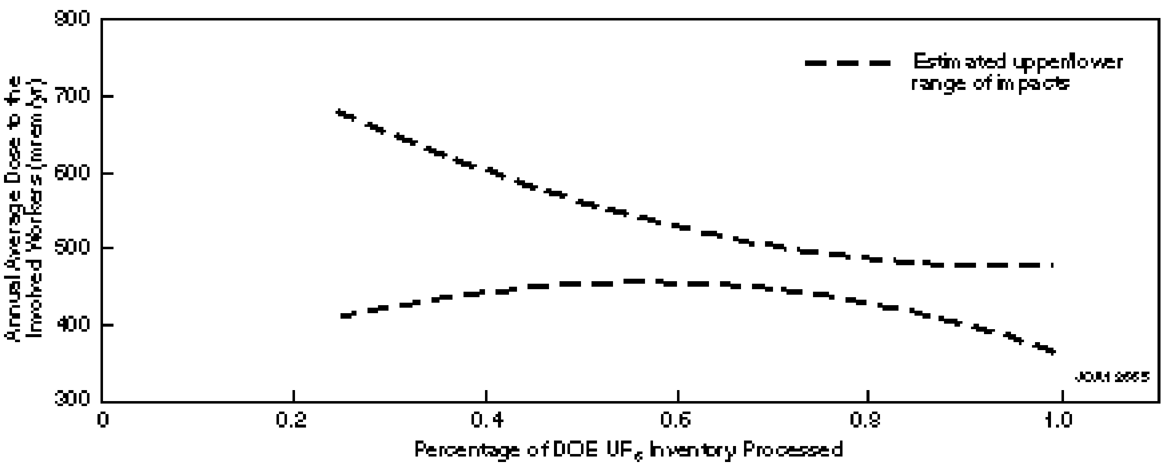

FIGURE K.66 Estimated Annual Average Individual Dose to Involved Workers from the Disposal of Ungrouted UO_2 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, and mine.)

In general, the results of the parametric analysis (as shown in Figures K.51 through K.66) indicate that the collective radiological impacts during the operational phase would decrease with the total quantity of depleted uranium disposed of. The impacts of the 25% and 50% cases would be smaller than those for the 100% case, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than half of the impacts for the 100% case). Overall, radiation doses would be larger for the disposal of grouted waste compared with ungrouted waste because of the additional activities required and the small emissions resulting from the grouting process. In some cases, the average individual worker dose might increase or decrease as the throughput increased, primarily because the number of workers required would not increase at the same rate as the collective dose. The doses shown in the figures can be converted to the number (or risk) of LCFs by multiplying the doses (in rem or person-rem) by 0.0005 LCF/person-rem for members of the general public and 0.0004 LCF/person-rem for workers. Additional discussion of the significance of the estimated doses is provided in Appendix I.

K.5.1.1.2 Post-Closure Phase

At some time in the future after the closure of the disposal facility, potential impacts could occur to the public through the use of contaminated groundwater and from external radiation if the cover materials eroded away. In general, the complete erosion of the cover material, especially for a vault or mine, would not occur until thousands of years after the facility had been closed. Therefore, external radiation exposures would not be expected within the time frame considered (i.e., 1,000 years). Even if complete erosion occurred, the radiation exposure could be reduced by adding new cover material. Groundwater contamination would not be expected to occur until hundreds to thousands of years after the disposal facility had been closed. The estimated groundwater concentrations and associated uncertainty are discussed in Appendix I. For assessment purposes, the MEI was assumed to live at the edge of the disposal site and to use groundwater for drinking, irrigating plant foods and fodder, and feeding livestock. The potential radiation doses from using contaminated groundwater were based on groundwater concentrations calculated in the groundwater analysis that is discussed in detail in Section K.5.4.2.

The results of the groundwater analysis for a representative dry location indicate that measurable groundwater contamination would not occur until over 10,000 years after failure of the disposal facility. Therefore, no radiation exposures of the public would be expected for thousands of years following disposal in a dry environment.

Potential radiation exposures of the general public would be much greater if the disposal site was located in a wet environment. The results of the analysis indicate that the radiation dose to an individual using contaminated groundwater could reach about 80 mrem/yr for the 25% case, 96 mrem/yr for the 50% case, and 110 mrem/yr for the 100% case (considering both grouted and ungrouted wastes and different disposal technologies); these impacts could occur 1,000 years after failure of the containers and engineering barriers if the soil properties were such that uranium was transported rapidly toward the groundwater (mobile situation). If the depleted uranium was classified as LLW, the radiation doses from using contaminated groundwater would exceed the dose limit of 25 mrem/yr specified in the *Code of Federal Regulations* (10 CFR Part 61) and DOE Order 5820.2a. However, radiation doses from contaminated groundwater could be reduced or eliminated by treating the water or by using an alternative source of water.

K.5.1.2 Chemical Impacts

K.5.1.2.1 Operational Phase

The estimated impacts from chemical exposures during the normal operation of full-scale (100%) disposal facilities are described in Appendix I, Section I.3.1.2. The results of the 100% case analyses for the operational phase indicated that noninvolved workers and members of the general public would receive essentially no exposures to chemicals for the disposal of ungrouted uranium material and very low exposures from disposal of grouted uranium material for all disposal facilities. No adverse health impacts would be expected for any of the disposal facilities considered. For the 100% cases, the calculated hazard indices were much less than 1 for all disposal options (a hazard index of greater than 1 indicates the potential for health impacts). For the parametric analysis of the 25% and 50% throughput cases, airborne emissions would be less than the 100% cases and extremely small (LLNL 1997a). Therefore, by comparison with the 100% case results, no adverse health impacts from chemical exposures would be expected for throughput rates between 25% and 100% for all disposal options.

K.5.1.2.2 Post-Closure Phase

As for radiological impacts, potential chemical impacts could occur to the general public at sometime in the future through use of contaminated groundwater. The potential chemical impacts to an MEI resulting from use of contaminated groundwater were determined on the basis of the same assumptions discussed in Section K.5.1.1 for radiological exposures. Chemical exposures were calculated for a time 1,000 years after the disposal facility was assumed to fail. The potential chemical impacts from using contaminated groundwater were based on the groundwater concentrations calculated in the groundwater analysis (see Section K.5.4.2).

Because of the low precipitation rate in a dry location, it would take more than 10,000 years for the uranium compounds to reach the groundwater after the first contact with infiltration water. Therefore, no chemical exposures would occur to an individual living next to the disposal site in a dry environment within 10,000 years.

Chemical exposures to the MEI could potentially be much greater if the disposal site was located in a wet environment. The concentrations of uranium in groundwater at 1,000 years after failure of the disposal facility would be such that potential adverse health impacts from chemical exposures could result to an individual using contaminated groundwater for all cases. Risks from chemical exposures were quantified on the basis of calculated hazard indices. Assuming that the soil properties were such that uranium compounds could be transported rapidly toward the groundwater following failure of the containers and engineering barriers (at 1,000 years), the maximum hazard indices were estimated to be greater than 1, indicating a potential for adverse health effects. The hazard indices were calculated to be 8 for the 25% case, 10 for the 50% case, and 11 for the 100% case. However, chemical exposures from contaminated groundwater could be reduced or eliminated by treating the water or by using an alternative source of water.

K.5.2 Human Health — Accident Conditions

K.5.2.1 Radiological Impacts

The estimated radiological impacts (radiation doses and LCFs) from potential accidents during operation of full-scale (100%) disposal facilities are presented in Appendix I, Section I.3.2.1. The analysis of the 100% cases considered a range of accidents in four frequency categories; results are presented only for those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

Based on the assessment of the 25% and 50% disposal cases, the radiological accident impacts associated with each of the parametric cases would be the same as those presented for the 100% case in Appendix I. The impacts would be identical because the bounding accidents producing the greatest consequences within each frequency category would be the same for the 100%, 50%, and 25% cases. The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. However, as a result of the reduced throughput rates, the actual frequencies of some accidents related to handling operations (i.e., the “mishandle/drop of drum” accident) would decrease as the number of containers handled decreased. The resulting risk of these accidents would also decrease as their frequencies decreased. However, none of the accident frequencies would change enough to cause the accident to be considered in a different frequency category. Therefore, the overall impacts associated with the disposal options would be the same for all parametric cases.

K.5.2.2 Chemical Impacts

The estimated chemical impacts from potential accidents during full-scale (100%) operation of disposal as grouted or ungrouted UO_2 or U_3O_8 in shallow earthen structures, vaults, or a mine are presented in Appendix I, Section I.3.2.2. The analysis of 100% cases considered a range of accidents in four frequency categories; results are presented for only those accidents in each category that would have the greatest consequences (bounding accidents). Similar sets of accidents covering the same four frequency categories are defined in the engineering analysis report (LLNL 1997a) for the 25% and 50% throughput cases.

The bounding chemical accidents associated with the 25% and 50% throughput cases that would produce the greatest consequences would be the same as those presented for the 100% case. The impacts would be similar because the accidents within most frequency categories would be the same for the 100%, 50%, and 25% cases, and in those cases where these accidents were different, no adverse chemical impacts were estimated to occur. The bounding accidents would be the same because they would involve only a limited amount of material that would be at risk under accident conditions regardless of the facility size or throughput. However, some of the impacts for other accidents (nonbounding) considered for the 25% and 50% cases would be different from those for the 100% cases. In general, the impacts of the nonbounding accidents for the 50% and 25% cases would be less than those for the 100% cases because of the reduced throughput.

K.5.2.3 Physical Hazards

The estimated health impacts, such as on-the-job injuries and fatalities, from potential physical accidents during the construction and operation of full-scale (100%) disposal facilities are presented in Appendix I, Section I.3.2.3. For the 100% analysis, no on-the-job fatalities were estimated during construction and operation of a mine disposal facility (for ungrouted U_3O_8). The predicted number of on-the-job worker injuries for the 100% case is about 240. The impacts of the 25% and 50% cases would be smaller than those for the 100% case, although the decrease would not be proportional to the reduction in throughput (i.e., the impacts for the 50% case would be greater than 50% of the impacts for the 100% case).

The predicted number of on-the-job worker fatalities over the duration of disposal operations is less than 1, ranging from 0.4 for the 25% case to 0.53 for the 100% case (including construction and operations). The predicted number of on-the-job injuries (including construction and operations) ranges from 160 to 240. The number of injuries is shown as a function of throughput in Figure K.67.

K.5.3 Air Quality

The estimated impacts on air quality during construction and operation of full-scale (100%) disposal facilities are presented in detail in Appendix I, Section I.3.3. All of the pollutant concentrations produced by the 100% capacity version of the disposal facilities would be below their respective air quality standards. The annual average concentrations of NO_x might be as high as one-third of the air quality standards during operation of vault disposal facilities for grouted U_3O_8 in a wet environmental setting. During operations, all pollutant concentrations would be much less than the corresponding standards.

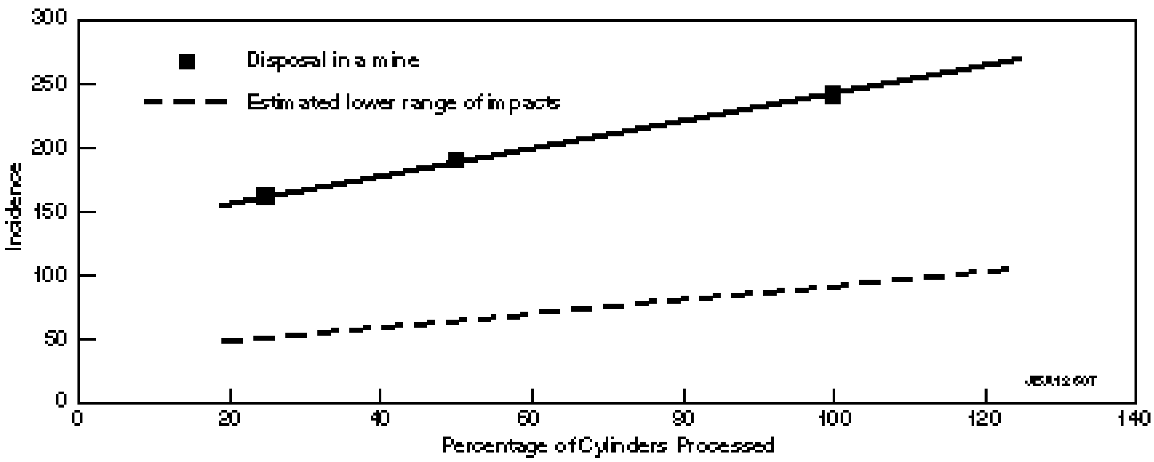

FIGURE K.67 Estimated Number of On-the-Job Injuries (for entire construction and operational periods) from the Disposal of Ungrouted U_3O_8 (The ranges reflect differences in disposal technologies, i.e., shallow earthen structures, vaults, or mine.)

The air quality impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% case. During construction, short-term impacts for the parametric cases would be less than those for the 100% case, and impacts during operations would also be less. Annual pollutant concentrations from construction of 50% and 25% capacity disposal facilities would be about 0.7 and 0.5 times as large as the full-capacity facility, respectively. For all the other disposal options, criteria pollutant levels would be lower percentages of their respective standards during both construction and operations.

K.5.4 Water and Soil

K.5.4.1 Surface Water

The estimated impacts on surface water during construction, operation, and potential accidents for full-scale (100%) disposal facilities are discussed in Appendix I, Section I.3.4. The actual impacts to surface water would depend on the ultimate site selected for disposal. However, for the generic sites considered in the PEIS, the impacts to surface water from the 100% case were found to be negligible for all disposal options for both the operational and post-closure phases. The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% case, and thus would also be negligible.

K.5.4.2 Groundwater

The estimated impacts on groundwater during construction, operation, and potential accidents for full-scale (100%) disposal facilities are presented in detail in Appendix I, Section I.3.4. The actual impacts to groundwater would depend on the ultimate site selected for disposal. However, during the operational phase, which would include construction and disposal activities, negligible impacts to groundwater would be expected. As described in Appendix I, the impacts to groundwater from the 100% case were expected to be negligible for the operational phase of all disposal options. The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were found to be less than those for the 100% case, and thus would also be negligible.

Impacts to groundwater during the post-closure phase are discussed in Section I.4.2. Groundwater impacts during the post-closure phase would be limited to changes in quality caused by contamination migrating from the disposal facility hundreds to thousands of years in the future after failure of the engineered barriers. There would be no impacts to effective recharge, depth to groundwater, or flow direction once the facility was constructed.

Disposal facility failure would generally occur hundreds to thousands of years in the future (assuming no sustained effort to maintain the facility). This failure would be caused by natural degradation of the disposal structures over time, primarily from physical processes such as the intrusion of water. Following failure, the release of uranium from the facility would occur very slowly as water moved through the disposed material. The amount of groundwater contamination, as well as the length of time it would take for the groundwater to become contaminated, would depend on the integrity of the drums and the engineering barriers, as well as the site-specific properties of the soil surrounding the disposal facility. Without more precise information concerning the expected lifetimes of the containers and engineering barriers in the specific disposal facility environment, as well as site-specific soil and hydrological properties, the groundwater concentrations estimated for the analysis presented in this appendix using generic assumptions are subject to a large degree of uncertainty. Nevertheless, if no remedial actions were taken, once the release of uranium from the disposal facility began, it could last for millions of years for all three cases (25%, 50%, and 100%).

If the disposal site were located in a dry environment, all of the resulting uranium concentrations in groundwater would be essentially zero for at least 1,000 years in the future (Tomasko 1997) for disposal of 25%, 50%, and 100% of the uranium material. In a wet climate, however, the uranium concentrations in the groundwater beneath a mined facility for ungrouted U_3O_8 would range from about 260 pCi/L (1,000 µg/L) for the 25% capacity case to 350 pCi/L (1,400 µg/L) for 100% capacity if the soil properties were such that the uranium moved rapidly through the soil (a retardation factor of 5). These uranium concentrations would exceed the U.S. Environmental Protection Agency (EPA) proposed maximum contaminant level of 20 µg/L (EPA 1996) used as a guideline in this PEIS. If the uranium were less mobile in the soil surrounding the disposal facility (retardation coefficient of 50), uranium concentrations in the groundwater beneath the facility after 1,000 years for disposal of 25%, 50%, and 100% would be less than 20 µg/L. However, the concentrations would increase with time, ultimately approaching the concentrations that would occur under the mobile situation and exceeding 20 µg/L.

Post-closure impacts to groundwater quality resulting from disposal in an underground mine could be reduced by decreasing the size of the facility in a direction parallel to the direction of groundwater flow, thereby increasing dilution (Tomasko 1997).

K.5.4.3 Soil

The estimated impacts to soil during construction, operation, and potential accidents for full-scale (100%) disposal facilities are presented in Appendix I, Section I.3.4. The potential impacts evaluated included changes in topography (land elevation), permeability (ability to let water enter the ground), quality, and erosion potential for a dry and wet location. Although impacts were evaluated for dry and wet conditions, the impacts would be essentially the same for both locations.

As discussed in Appendix I, the impacts to soil from the 100% cases were found to have potentially moderate to large, but temporary, impacts for the disposal options. These impacts would result from material excavated during disposal facility construction that would be left on-site. For example, construction of a mine for ungrouted U_3O_8 disposal would require excavating about 1.2 million yd^3 (920,000 m^3) of consolidated material. In the short term, this amount of material would cause changes in site topography. In the long term, contouring and reseeding would return soil conditions to their former state, and the impacts would be minor. The impacts calculated for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), were also found to have potentially large, but temporary, impacts on soil, similar to the 100% cases. In the long term, impacts on soil would be minor for all disposal options.

K.5.5 Socioeconomics

The socioeconomic impacts of ungrouted U_3O_8 mine disposal facilities for the 50% and 25% parametric cases would be less than the impacts of the base-case facility sizes. Cost information was not available in sufficient detail to allow an analysis of impacts using the same methodology that was used for the base cases. The impacts of parametric cases were therefore assessed qualitatively, based on the assumption that changes in the cost of equipment, materials, and labor would be proportional to changes in total life-cycle cost. Compared with base-case facility sizes, smaller U_3O_8 mine disposal facilities would create less direct employment and income at the site.

K.5.6 Ecology

Site preparation for the construction of a facility for the disposal of ungrouted U_3O_8 in a mine would result in the disturbance of biotic communities, including the permanent replacement of habitat with structures and paved areas. Existing vegetation would be destroyed during land-clearing activities. Wildlife would be disturbed by land clearing, noise, and human presence.

This disposal option would result in elevation of the soil surface by approximately 2.8 to 4.1 ft (0.85 to 1.2 m) and a reduction in soil permeability. The excavated material would primarily consist of rock removed from the drifts and ramps. The consequent decrease in surface soil moisture would make reestablishment of vegetation difficult and delay the establishment of native plant communities. Construction of a disposal facility for ungrouted U_3O_8 in a mine would result in a large adverse impact to existing vegetation and wildlife.

Impacts to wetlands and state and federally protected species due to facility construction would depend on facility location. Avoidance of wetland areas would be included during facility planning. Site-specific surveys for protected species would be conducted prior to finalization of facility siting plans.

Impacts to air, surface water, groundwater, and soil quality during construction are expected to be negligible for the 25%, 50%, and 100% cases (Sections K.5.3 and K.5.4). Resulting construction-derived impacts to ecological resources would also be expected to be negligible. Impacts to ecological resources from air and water emissions would also be negligible during the operational phase of the disposal options.

During the post-closure phase, failure of facility integrity could result in contamination of groundwater (see Section K.5.4.2). Groundwater could discharge to the surface (such as in wetland areas) near the facility, thus exposing biota to contaminants. Groundwater concentrations of uranium calculated for 1,000 years after failure of a mined facility for ungrouted U_3O_8 would range from about 260 to 350 pCi/L for the 25% and 100% cases, respectively. Similarly, groundwater concentrations for a mined facility for grouted U_3O_8 would range from about 310 to 425 pCi/L for the 25% and 100% cases, respectively. Adverse impacts to aquatic biota could result from exposure to soluble uranium compounds within this concentration range. Resulting dose rates to maximally exposed organisms would be less than 2% of the dose limit of 1 rad/d, for aquatic organisms, as specified in DOE Order 5400.5.

K.5.7 Waste Management

The estimated impacts from waste management operations from the construction and operation of full-scale (100%) disposal facilities are presented in detail in Appendix I, Section I.3.7. The impacts on national waste management operations from construction of disposal facilities were found to be negligible for the 100% throughput case. The impacts that would result from construction for the 25% and 50% parametric cases, based on information provided in the engineering analysis report (LLNL 1997a), would be less than those for the 100% case, and thus would also be negligible.

Operation of a disposal facility would generate radioactive, hazardous, and nonhazardous wastes (Section I.3.7). All of the secondary wastes listed would have a negligible impact on waste management capacities across the DOE complex. However, the product waste would represent a significant volume when compared with the complexwide total of LLW for disposal. Disposal of 100% of the depleted uranium inventory could represent from 1.1 to 7.3% of the total DOE LLW generated over roughly the same time period. Overall, the waste input resulting from the normal operation of the U_3O_8 disposal facility would have a negligible to low impact on DOE's complexwide waste management activities.

The parametric analysis of operational waste loads was conducted for throughput values of 25%, 50%, and 100% (Table K.5). Some of these analyses showed nonlinear effects, but the estimated impacts would be very small. The volume of product waste was shown to be linear with throughput. Thus, it was assumed that a linear interpolation could be used to estimate waste loads for throughput values other than 25%, 50%, and 100%.

K.5.8 Resource Requirements

The estimated impacts from resource requirements during construction and operation of full-scale (100%) disposal facilities are presented in detail in Appendix I, Section I.3.8. The impacts on resources, except for electrical consumption for a mine disposal facility, would be expected to

TABLE K.5 Wastes Generated during Facility Operations from the Disposal of Ungrouted U_3O_8

	Annual Waste Generated for Three Throughput Cases		
Waste Type	100%	50%	25%
Waste (m^3/yr)			
Solid LLW	81	57	40
Mixed liquid LLW	0.31	0.22	0.15
Nonhazardous waste (million L/yr)			
Solids	0.64	0.45	0.32
Wastewater	0.92	0.68	0.48
Product waste volume (m^3/yr)			
Ungrouted U_3O_8	7,440	3,720	1,860

be small for the 100% capacity case. Resource requirements for the 25% and 50% parametric cases considered would be less than those for the 100% case (LLNL 1997a).

Construction and operation of the disposal facilities would consume irretrievable amounts of electricity, fuel, concrete, steel and other metals, water, and miscellaneous chemicals. The total quantities of commonly used materials would not be expected to be significant. However, for a mine disposal facility, significant quantities of electrical energy would be required during construction (up to 1,100 MW-yr, orders of magnitude greater than that required for other disposal facility types) because the majority of the construction equipment used in the underground portion would be powered by electricity to avoid polluting the air in the underground work area. Similarly, compared with the other options, a relatively higher annual amount of electricity would be needed during underground operations. No strategic and critical materials would be expected to be consumed during construction or operation of the facilities. The disposal facility operations requirements would generally not be resource-intensive, and the resources required are not considered rare or unique. Furthermore, committing any of these resources (except for electrical consumption) would not be expected to cause a negative impact on the availability of these resources within local areas or nationally for the 100%, 50%, and 25% cases. The magnitude of impact of the high electrical requirement for a mine disposal facility on local energy resource usage would be dependent on the extent of existing site infrastructure.

K.5.9 Land Use

Potential moderate to large impacts from the construction and operation of a mined disposal facility would be expected from on-site disposal of excavated material. Potential traffic volume impacts would be associated with the construction labor force. Site preparation for the construction of a facility for the disposal of ungrouted U_3O_8 in a mine for 25%, 50%, and 100% of the depleted UF_6 inventory would require the disturbance of approximately 97, 165, and 232 acres (39, 66, and 93 ha), respectively. On-site topographical modifications associated with disposition of the excavated material could potentially affect future on-site land use, although such impacts would be small. Land use impacts from shallow earthen structure and vault options would range from negligible to moderate.

Impacts to land use outside the boundaries of a disposal facility would consist of temporary traffic impacts associated with project construction. The actual impacts would depend on the specific site chosen.

K.5.10 Other Impacts Considered But Not Analyzed in Detail

There are other impacts that can potentially occur if the disposal options considered in this PEIS are implemented. They include impacts to cultural resources and environmental justice, as well as to aesthetics (e.g., visual environment), recreational resources, and noise levels, and impacts associated with decontamination and decommissioning of surface disposal facilities. These impacts, although considered, were not analyzed in detail for one or both of the following reasons:

- The impacts could not be determined at the programmatic level without consideration of specific sites. These impacts would be more appropriately addressed in the second-tier NEPA documentation when specific sites are considered.

- Consideration of the impacts would not contribute to differentiation among the alternatives; therefore, it would not affect the decisions to be made in the Record of Decision that will be issued following publication of this PEIS.

K.6 TRANSPORTATION

The estimated environmental impacts were presented in Appendix J for transportation of materials associated with the 100% cases considered for the depleted uranium inventory options. Because the locations of the various facilities are not determined, impacts for three shipment distances (250, 1,000, and 5,000 km) were presented to give the reader a basis for understanding the ramifications of shipment distance on the impacts. In this appendix, all transportation impacts are presented for a single shipment distance of 1,000 km because the objective here is the comparison among the three cases of throughput (25%, 50%, and 100%) associated with the depleted uranium.

The transportation impacts are presented in the form of line graphs in terms of risk (estimated fatalities) as a function of the number of total shipments over the 20-year life of the project. Each graph pertains to a single type of shipment either by truck or rail mode. As in Appendix J, estimated fatality risks from radiological (routine and accident), chemical (accident), and vehicle (routine and accident) causes are presented in each graph. The 25%, 50%, and 100% throughput cases are denoted with vertical lines on each graph.

K.6.1 Conversion Options

The conversion of the depleted UF_6 to an oxide or a metal form might require shipment of the depleted uranium to an off-site facility. Impacts for the 100% case are presented in Appendix J, Section J.3.4. Figures K.68 and K.69 present the results for shipping the depleted uranium cylinders either by truck or rail, respectively, for the three parametric cases. The 100% case risks for cylinder shipment are presented in Tables J.5 and J.6 in Section J.3.4.1. The impacts from routine external radiation if overcontainers were to be used are also presented. The radiological and chemical risks from accidents are not presented because these risks would be at least 100 times less than the other estimated risks.

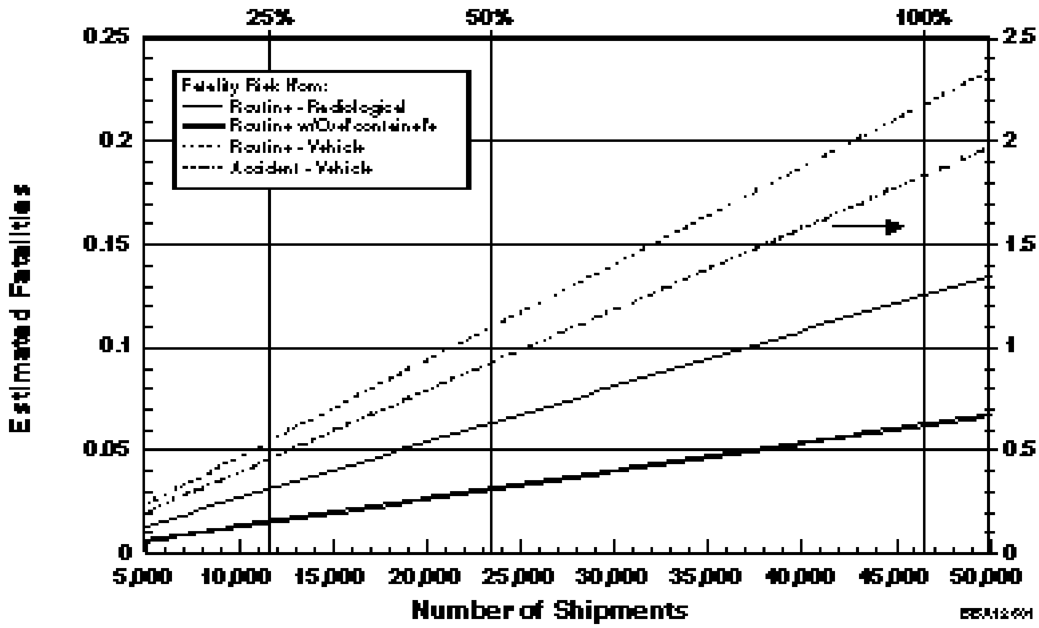

FIGURE K.68 Estimated Truck Transportation Risks for Depleted UF_6 Cylinders

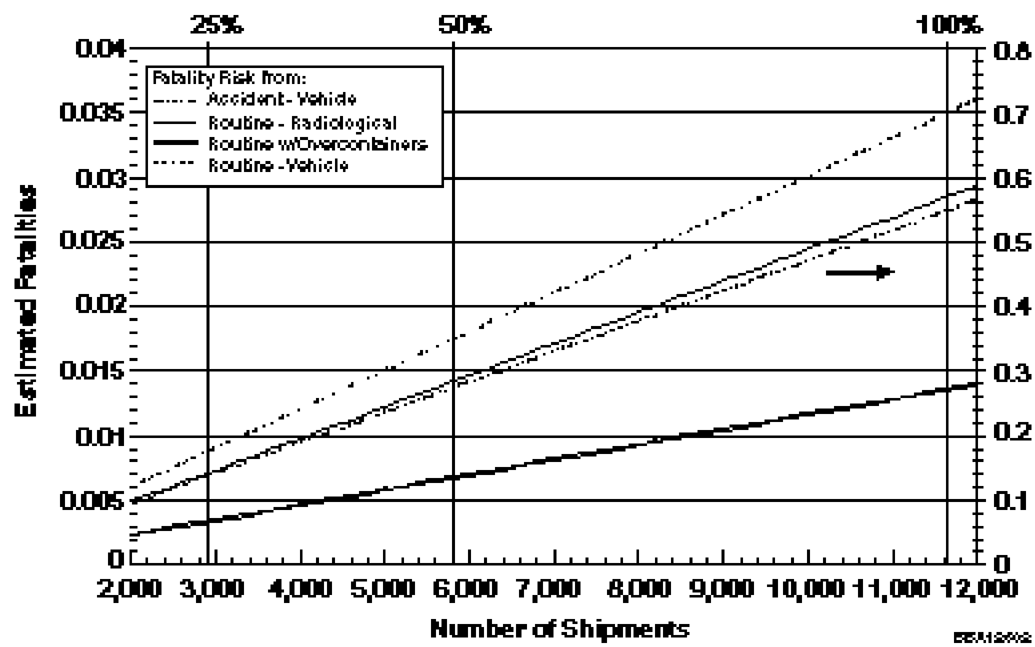

FIGURE K.69 Estimated Rail Transportation Risks for Depleted UF_6 Cylinders

Conversion of the depleted UF_6 to an oxide or uranium metal would involve transportation of input materials and output waste forms, as discussed in Appendix J, Section J.3.4. Ammonia might be used as an input material for oxide and metal conversion; Figure K.70 presents the chemical and vehicle risks from transportation of ammonia for shipment by rail for UO_2 or metal conversion. Anhydrous HF is a common product of the three conversion technologies studied for the parametric analysis. The two oxide technologies would produce about the same amount of HF for the same amount of depleted UF_6 input, an amount that is about three times the amount of HF produced in the conversion to metal. Figure K.71 presents the parametric risks for HF transport. The conversion-to-metal process would produce a large quantity of nonhazardous MgF_2 as another by-product. The vehicle-related parametric risks for transport of MgF_2 by truck and rail are shown in Figures K.72 and K.73, respectively.

Both LLW and low-level mixed waste (LLMW) would be produced at a conversion facility and would require transport for disposal, as discussed in Appendix J, Section J.3.4.2. The number of shipments required for LLMW disposal in all three options is not expected to change with the throughput case (25%, 50%, or 100%) because a minimal amount would be generated by the conversion process. The estimated transportation risks for the LLW generated at the three different conversion facilities shipped to a disposal site are presented in Figures K.74 through K.76.

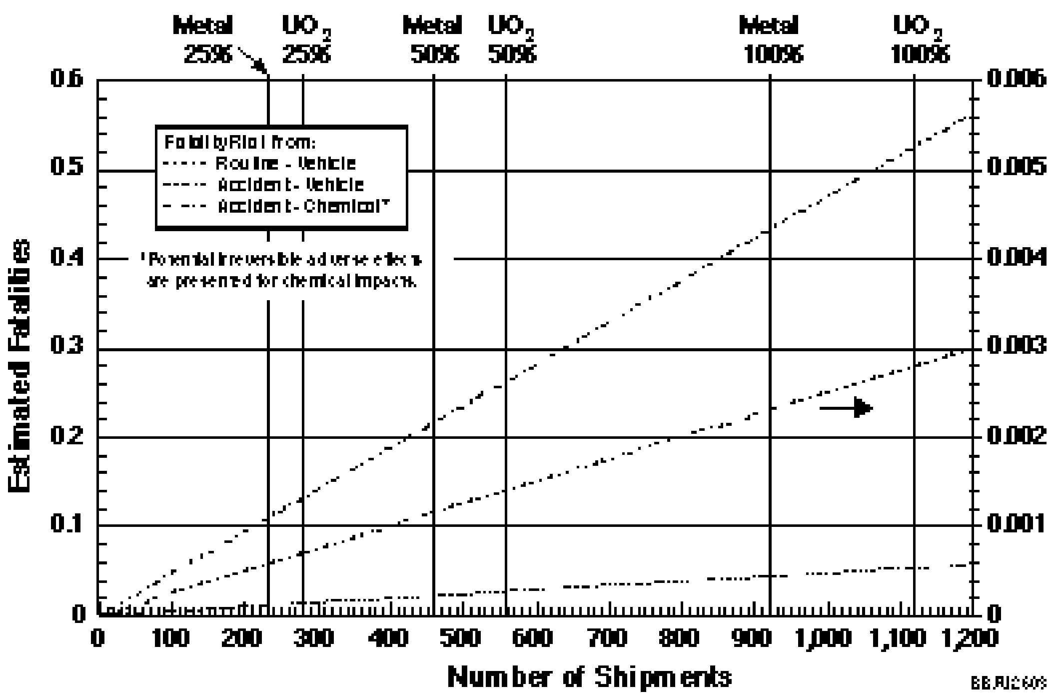

FIGURE K.70 Estimated Rail Transportation Risks for the Ammonia Used in the Conversion of Depleted UF_6 to UO_2 or Uranium Metal

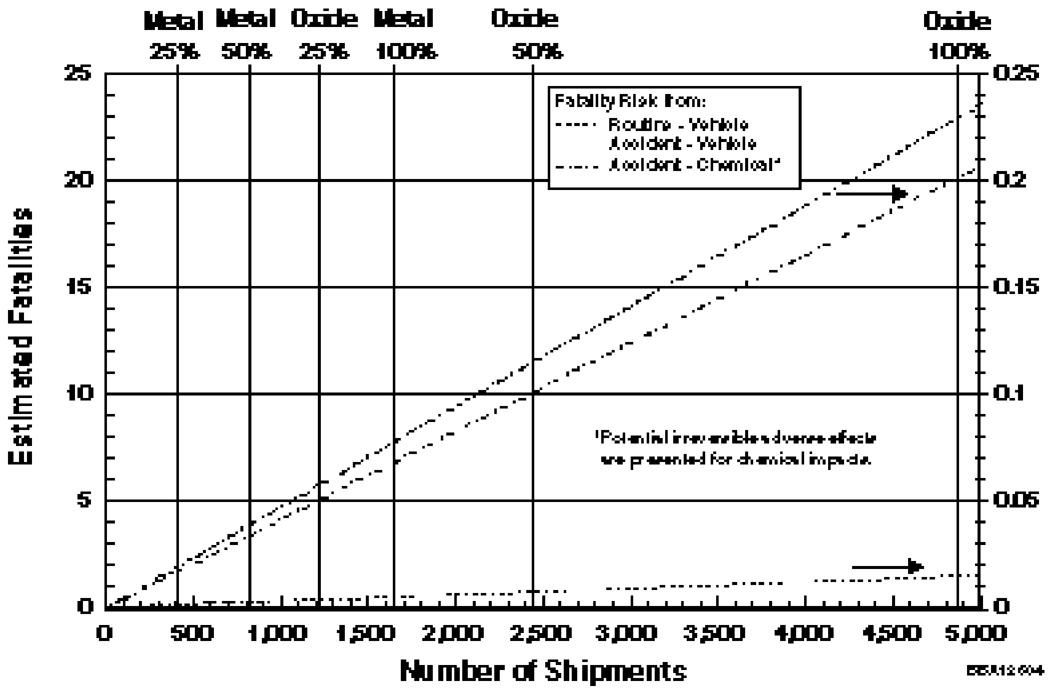

FIGURE K.71 Estimated Rail Transportation Risks for the HF Produced in the Conversion of Depleted UF_6 to U_3O_8, UO_2, or Uranium Metal

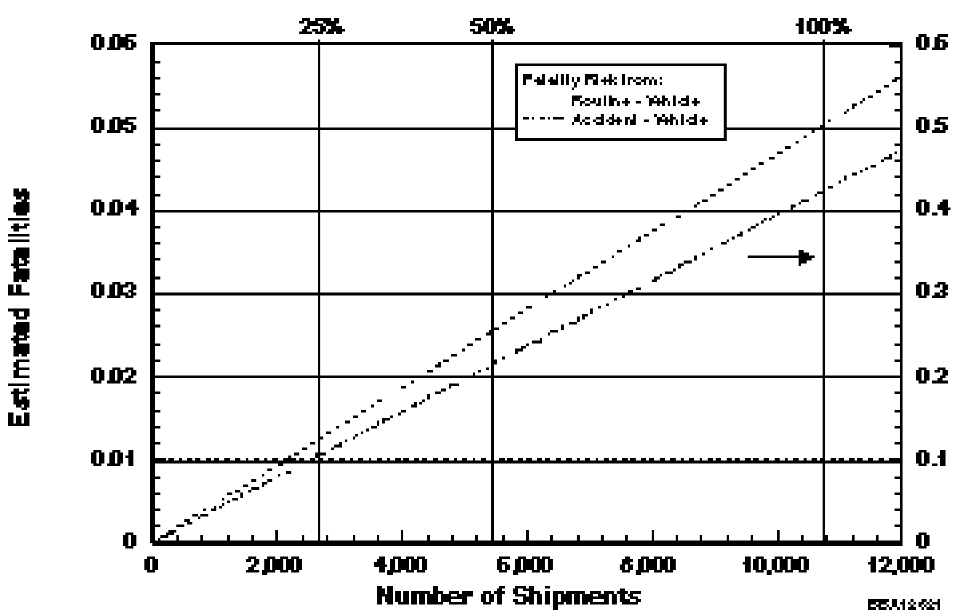

FIGURE K.72 Estimated Truck Transportation Fatality Risks for the MgF_2 Generated in the Conversion of Depleted UF_6 to Uranium Metal

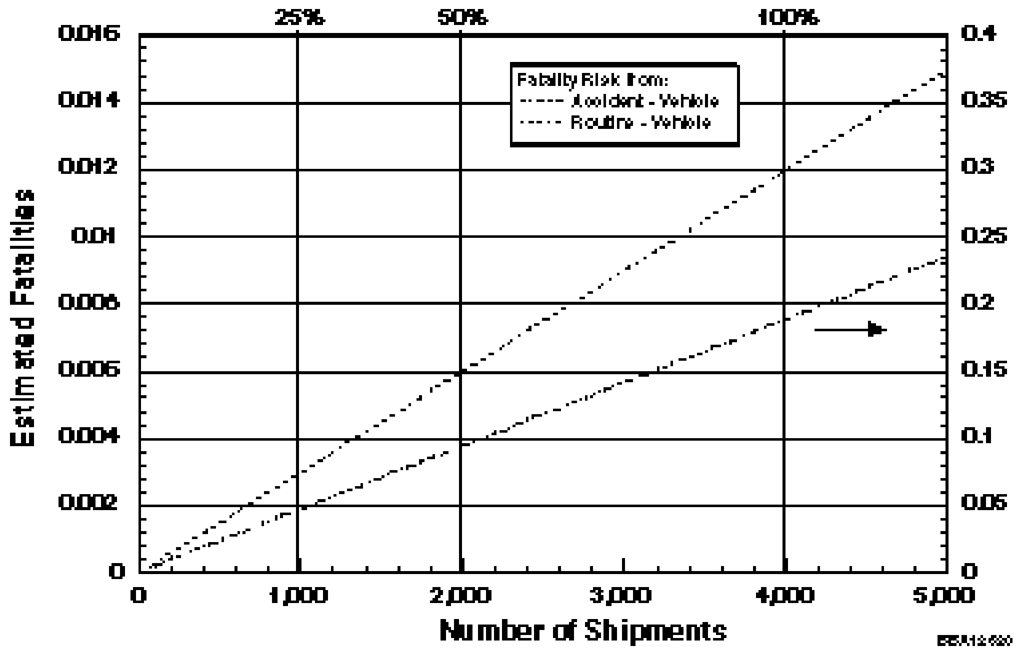

FIGURE K.73 Estimated Rail Transportation Fatality Risks for the MgF_2 Generated in the Conversion of Depleted UF_6 to Uranium Metal

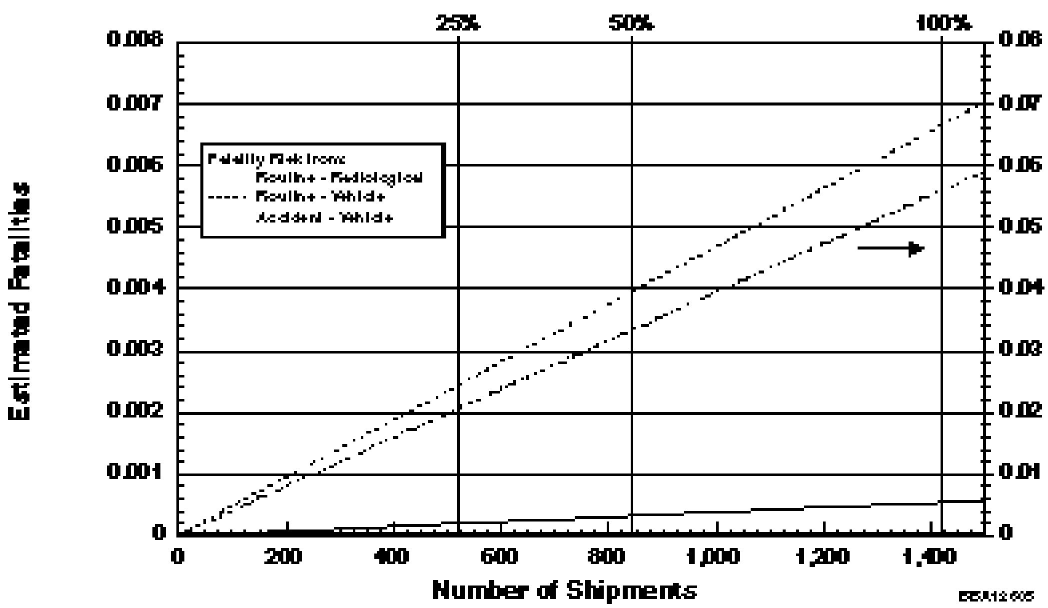

FIGURE K.74 Estimated Truck Transportation Risks for the LLW Generated in the Conversion of Depleted UF_6 to U_3O_8

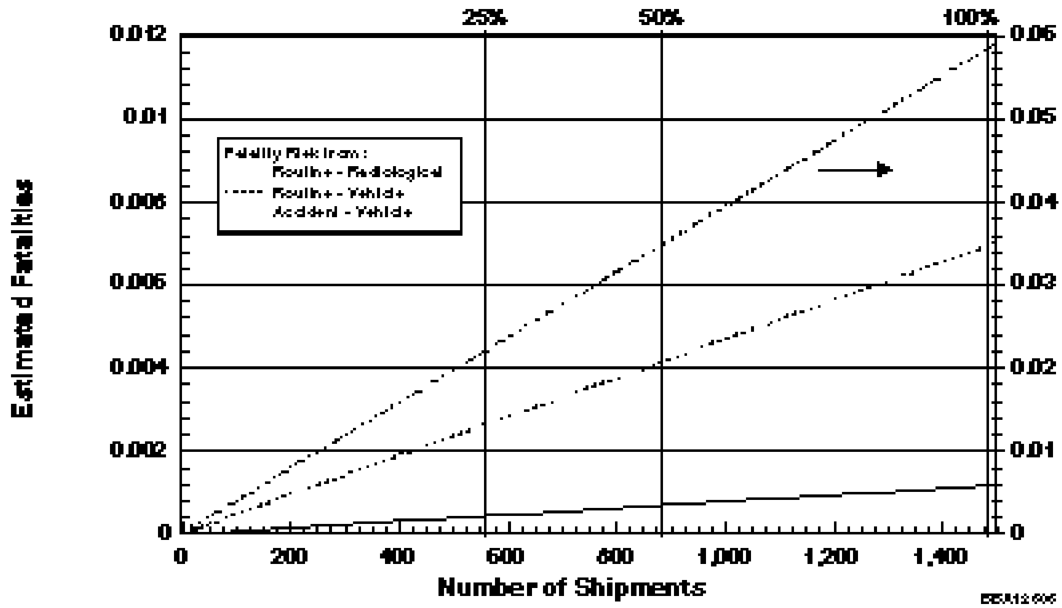

FIGURE K.75 Estimated Truck Transportation Risks for the LLW Generated in the Conversion of Depleted UF$_6$ to UO$_2$

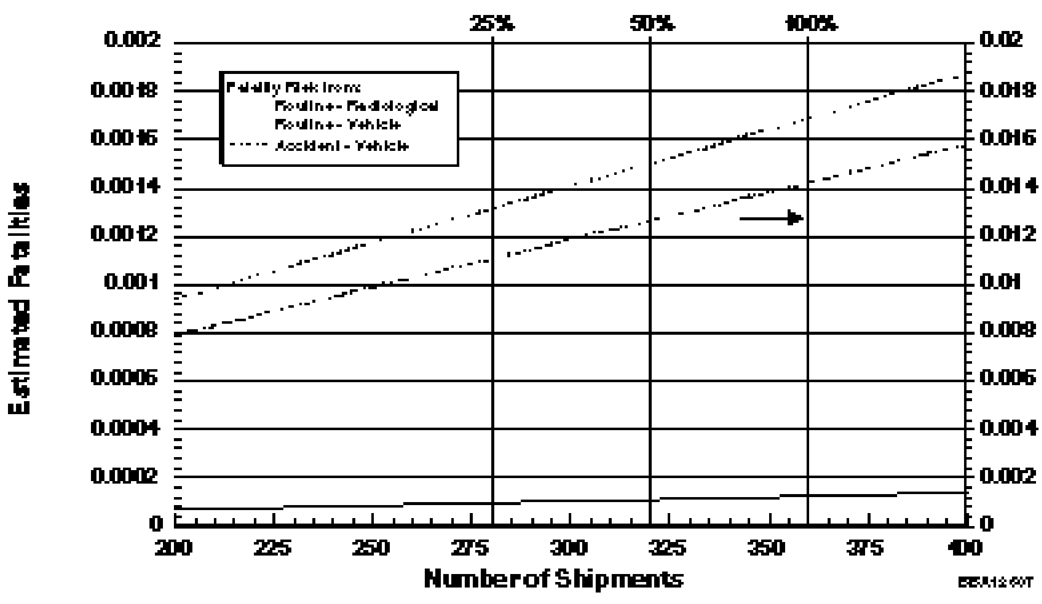

FIGURE K.76 Estimated Truck Transportation Risks for the LLW Generated in the Conversion of Depleted UF$_6$ to Uranium Metal

Radiological and chemical risks from accidents are not presented because they would be at least 100 times less than the other estimated risks.

Parametric transportation risks for the shipment of U_3O_8 are provided in Section K.6.4 under the U_3O_8 disposal option. Parametric transportation risks for the UO_2 conversion product are discussed in Section K.6.2 under the UO_2 long-term storage option, and the risks for the metal conversion product are discussed in Section K.6.3 for the manufacture and use option.

Each conversion option would require cleaning of the empty depleted UF_6 cylinders at the cylinder treatment facility, as discussed in Appendix J, Section J.3.4.3. The parametric transportation risks for the resulting LLW and U_3O_8 are presented in Figures K.77 and K.78, respectively. For the LLW shipments, the radiological and chemical risks are not presented because they are at least 100 times less than the vehicle emission risks, as shown in Appendix J, Section J.3.4.3. The number of shipments required for the LLMW generated at the cylinder treatment facility is not expected to change appreciably with the throughput case (25%, 50%, or 100%) because a minimal amount would be generated by the cleaning process.

K.6.2 Long-Term Storage Options

Storage as UF_6 in buildings assumes transportation of the depleted UF_6 cylinders to a storage site. Parametric risks from transportation of the depleted UF_6 cylinders is discussed in Section K.6.1. A very small amount of LLW and LLMW would be generated from occasional cylinder failure during the surveillance phase of this option. The type of waste generated would be similar to that generated at the cylinder treatment facility and would have similar single shipment risks. As discussed in Appendix J, Section J.3.5, less than one shipment per year is expected for the 100% case, with slightly fewer shipments necessary for the 50% and 25% cases.

Transportation of UO_2 from a conversion facility might be required for long-term storage as oxide, as discussed in Appendix J, Section J.3.5. Figures K.79 and K.80 present the results for shipping the UO_2 conversion product exclusively by truck or rail, respectively, for the three parametric cases. The chemical accident risks for UO_2 are not presented because they would be more than 100 times less than the routine radiological risks shown in Tables J.11 and J.12 for the 100% case.

K.6.3 Manufacture and Use Options

K.6.3.1 Use as Uranium Oxide

The estimated transportation risks for shipment of all the UO_2 from a conversion facility to a manufacturing site for uranium oxide cask production are presented in Appendix J,

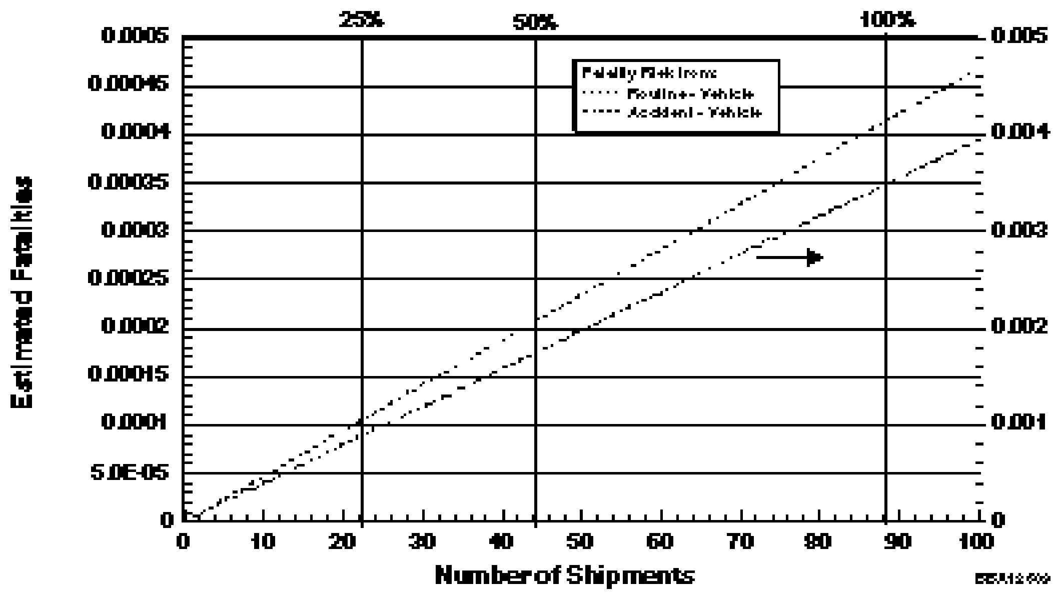

FIGURE K.77 Estimated Truck Transportation Risks for the LLW Generated at the Cylinder Treatment Facility

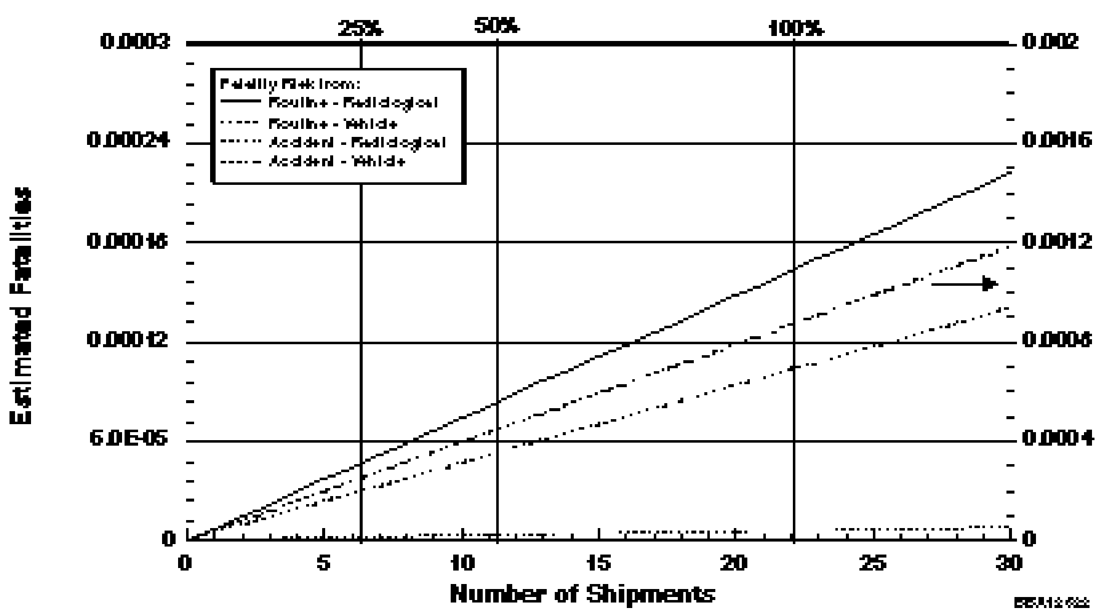

FIGURE K.78 Estimated Truck Transportation Risks for the U_3O_8 Generated at the Cylinder Treatment Facility

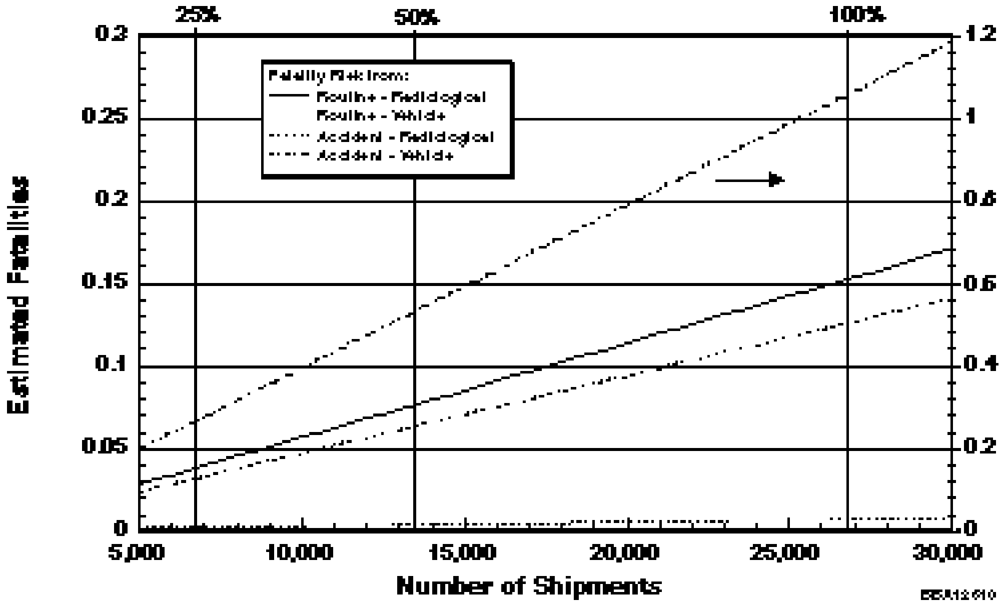

FIGURE K.79 Estimated Truck Transportation Risks for UO_2 Shipped from the Conversion Facility to Long-Term Storage or Oxide Cask Manufacture

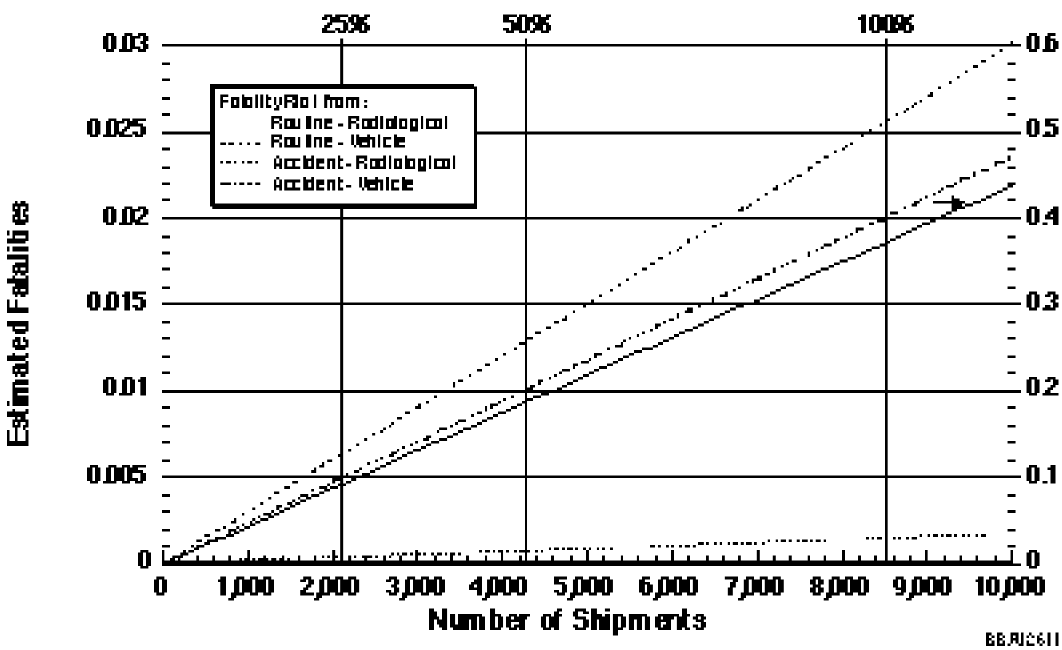

FIGURE K.80 Estimated Rail Transportation Risks for UO_2 Shipped from the Conversion Facility to Long-Term Storage or Oxide Cask Manufacture

Section J.3.6.1. The parametric risks for UO_2 are shown in Figures K.79 and K.80 for shipment by truck and rail, respectively.

Uranium oxide cask production would result in the generation of some LLW and LLMW, as discussed in Appendix J, Section J.3.6. The parametric results for the shipment of the LLW by truck to a disposal site are shown in Figure K.81. Radiological and chemical accident risks are not presented because they are more than 1 million times less than the other results shown in Tables J.15 and J.16 for the 100% case. The number of shipments required for LLMW disposal is not expected to change appreciably with the throughput case (25%, 50%, or 100%) because a minimal amount would be generated by the manufacturing process.

The transportation risks for shipment of the uranium oxide cask by rail from the manufacturing facility to an end-user are given in Appendix J, Section J.3.6.1. Figure K.82 shows the risks associated with rail shipments of the uranium oxide casks for the three parametric cases. Radiological and chemical accident risks are not presented because they are approximately 1 million times less than the other results shown in Tables J.15 and J.16 for the 100% case.

K.6.3.2 Use as Uranium Metal

The estimated transportation risks for shipment of all of the uranium metal from a conversion facility to a manufacturing site for metal cask production are presented in Appendix J, Section J.3.6.2. The parametric risks for the metal shipments are presented in Figures K.83 and K.84 for shipment by truck or rail, respectively. Radiological and chemical accident risks are not presented because they would be more than 1 million times less than the other results shown in Tables J.15 and J.16 for the 100% case.

The metal cask production would result in the generation of some LLW and LLMW, as discussed in Appendix J, Section J.3.6.2. The parametric results for the shipment of the LLW by truck to a disposal site are shown in Figure K.85. Radiological and chemical accident risks are not presented because they would be more than 100 times less than the other risks shown. The number of shipments required for LLMW disposal is not expected to change appreciably with the throughput case (25%, 50%, or 100%) because a minimal amount is generated by the manufacturing process.

The transportation risks for shipment of the metal cask by rail from the manufacturing facility to an end-user are given in Appendix J, Section J.3.6.2. Figure K.86 shows the risks associated with rail shipment of the metal casks for the three parametric cases. Routine radiological risks are not presented because these risks would be about 100 times less than the risks for the 100% case; radiological and chemical accident risks are also not presented because they would be approximately 100 million times less than the other risks for the 100% case, as shown in Tables J.15 and J.16.

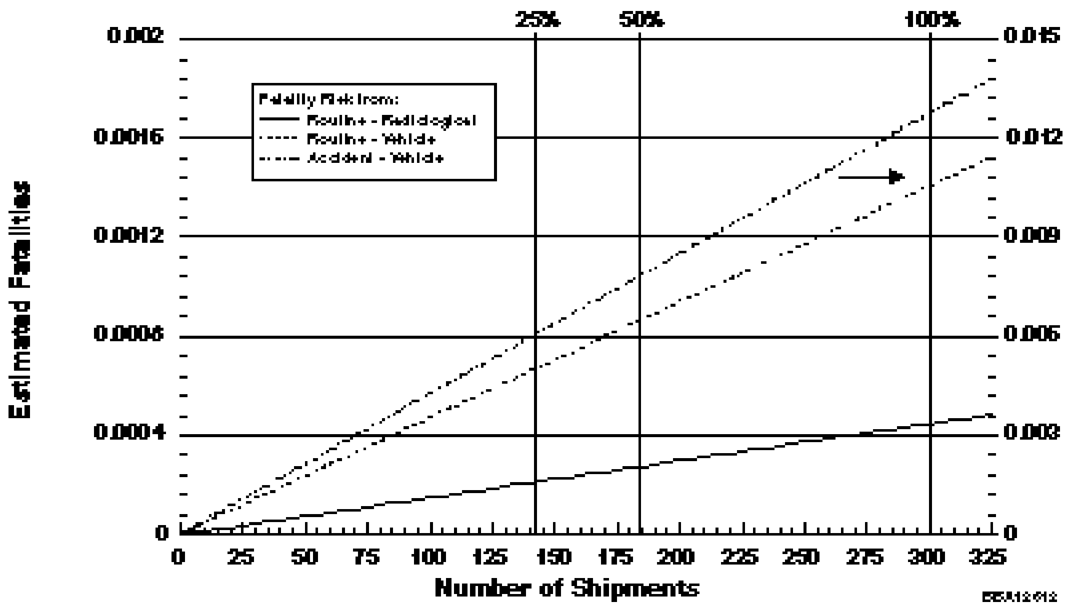

FIGURE K.81 Estimated Truck Transportation Risks for Shipment of LLW from the Oxide Cask Manufacturing Facility to a Disposal Site

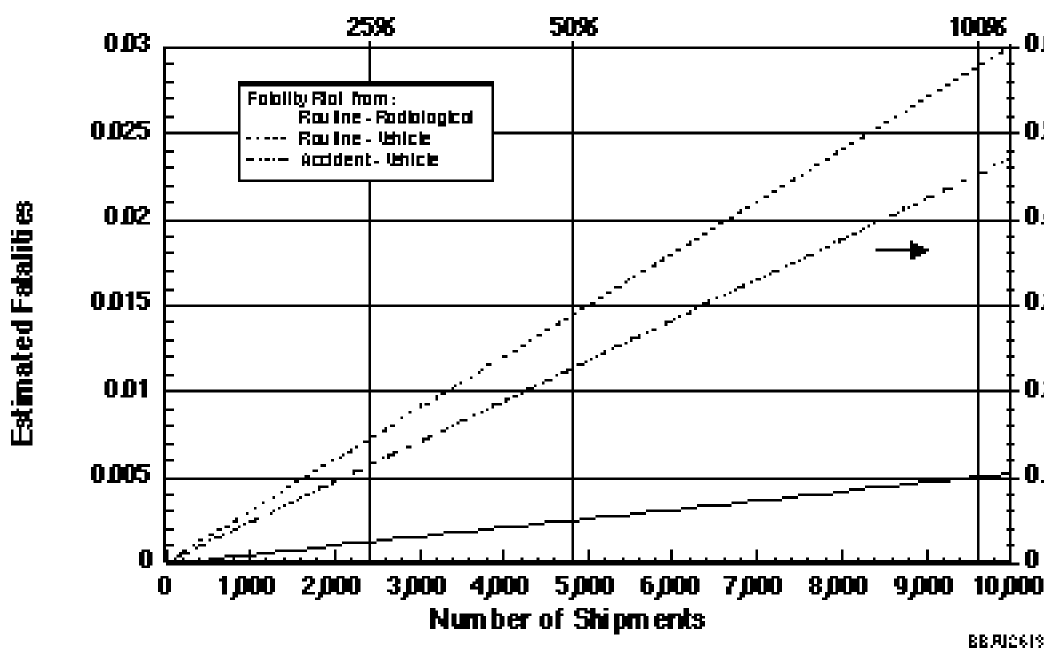

FIGURE K.82 Estimated Rail Transportation Risks for Shipment of Oxide Casks from the Cask Manufacturing Facility to an End-User Site

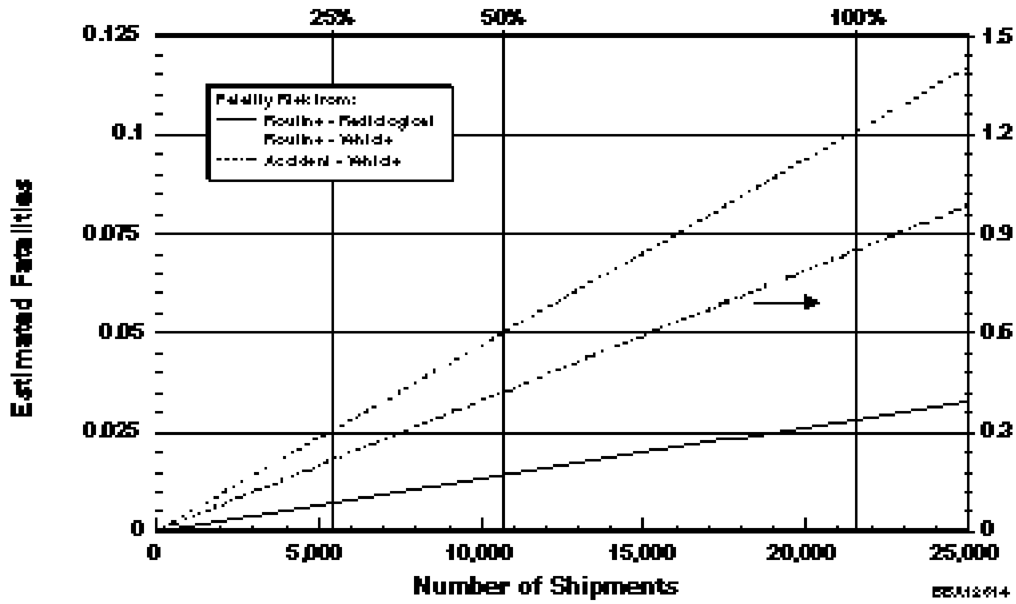

FIGURE K.83 Estimated Truck Transportation Risks for Uranium Metal Shipped from the Conversion Facility to Metal Cask Manufacture

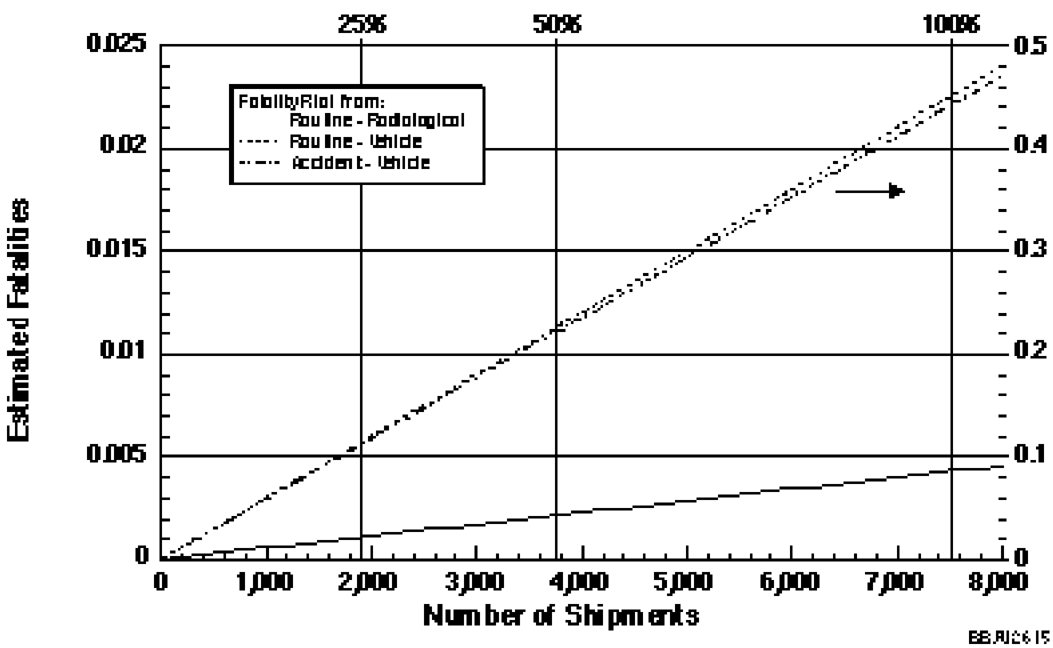

FIGURE K.84 Estimated Rail Transportation Risks for Uranium Metal Shipped from the Conversion Facility to Metal Cask Manufacture

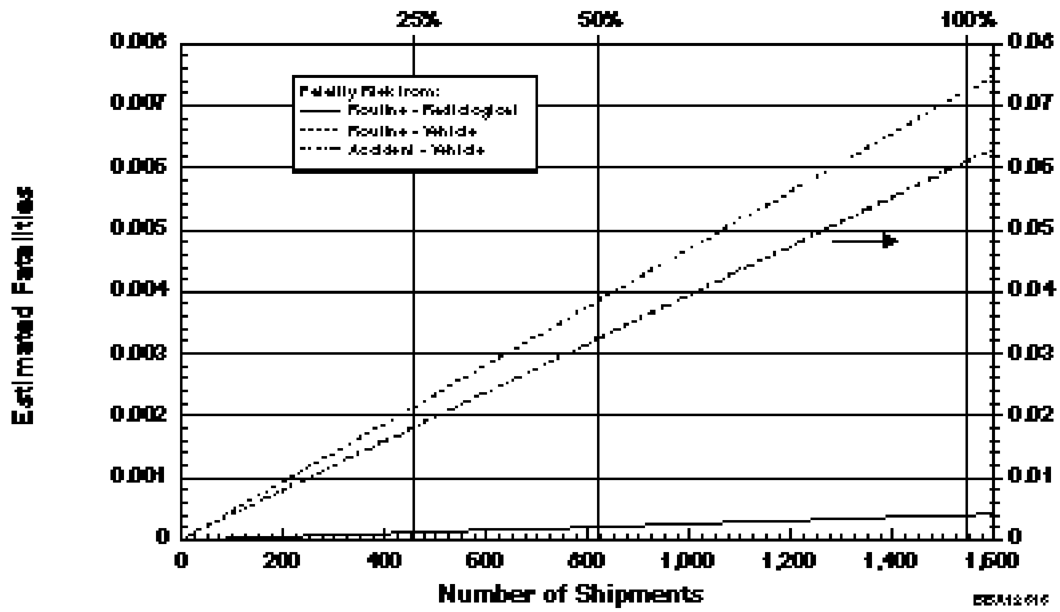

FIGURE K.85 Estimated Truck Transportation Risks for Shipment of LLW from the Metal Cask Manufacturing Facility to a Disposal Site

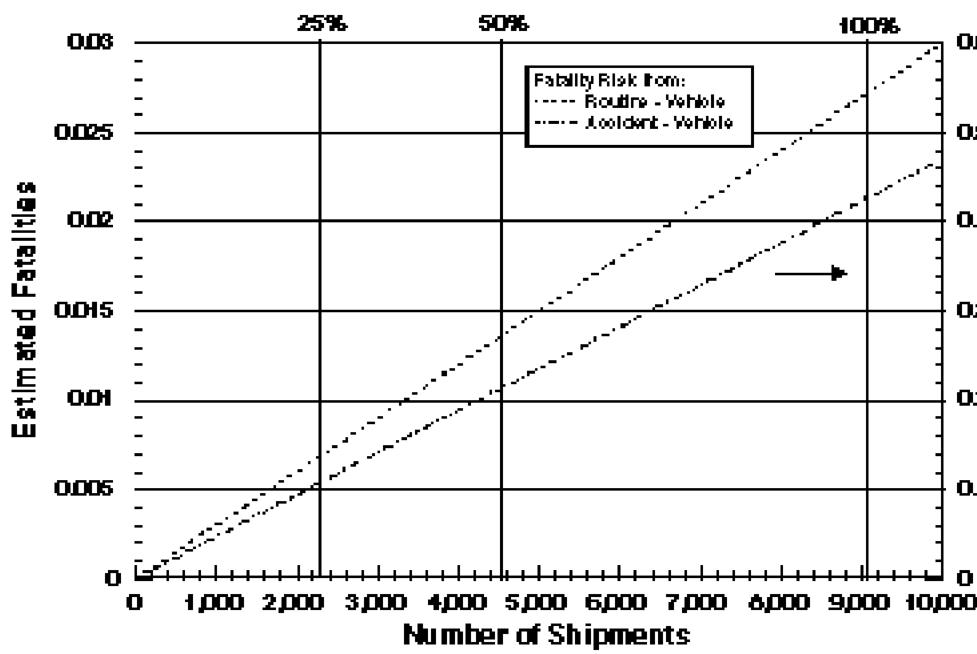

FIGURE K.86 Estimated Rail Transportation Risks for Shipment of Metal Casks from the Cask Manufacturing Facility to an End-User Site

K.6.4 Disposal as Ungrouted U_3O_8

The estimated transportation risks for shipment of all the U_3O_8 from a conversion facility to a disposal site are presented in Appendix J, Section J.3.7. The parametric risks for the oxide shipments are presented in Figures K.87 and K.88 for shipment by truck or rail, respectively.

K.7 IMPACTS OF COMBINATIONS OF ALTERNATIVES

The alternatives evaluated in detail in the PEIS are no action, long-term storage as UF_6, long-term storage as uranium oxide, use as uranium oxide, use as uranium metal, and disposal. DOE's preferred alternative is also considered in the PEIS. This section provides examples of how the impacts of parametric cases for continued storage, cylinder preparation, conversion, long-term storage, manufacture and use, disposal, and transportation activities (as presented in Appendixes D and E and Sections K.2-K.6 of Appendix K) can be added together to assess the impacts of strategies that combine one or more of the alternatives evaluated in the PEIS. Six example combinations of use as oxide, use as metal, and continued storage as UF_6 are evaluated (cases 1 through 6); an additional combination of 50% use as oxide, 50% use as metal (case 7) is also evaluated. Although these combinations were chosen as examples, the methods to calculate potential environmental impacts for them can be used to calculate impacts for other combinations as well (e.g., 50% disposal, 50% long-term storage).

The example combinations assessed (Table K.6) were selected to provide a reasonable range of possible combinations that might occur in the future as uses are identified. A summary of potential environmental consequences associated with these cases is presented in Tables K.9 and K.10 (tables follow Section K.7.2 of this appendix).

K.7.1 Example Calculation of Impacts for a Combination of Alternatives

The results of a sample calculation for Case 1 are presented in Sections K.7.1.1 through K.7.1.11. Under Case 1, 50% of the depleted UF_6 inventory would continue to be stored as UF_6, 25% would be converted and used as uranium oxide, and the remaining 25% would be converted and used as uranium metal. This sample is intended to illustrate how the impacts can be estimated for any combination of alternatives.

The impacts for this sample combination include impacts during continued cylinder storage, preparation of cylinders for shipment, conversion of UF_6 to uranium oxide and metal, treatment of empty cylinders, manufacture of uranium oxide and uranium metal casks, and transportation of cylinders, conversion products (oxide, metal, HF, ammonia, and waste), and casks. The potential impacts of Case 1 were calculated by adding the impacts from each of the individual components, as appropriate. Certain impacts, such as the dose to MEIs, are not additive because the MEI at each

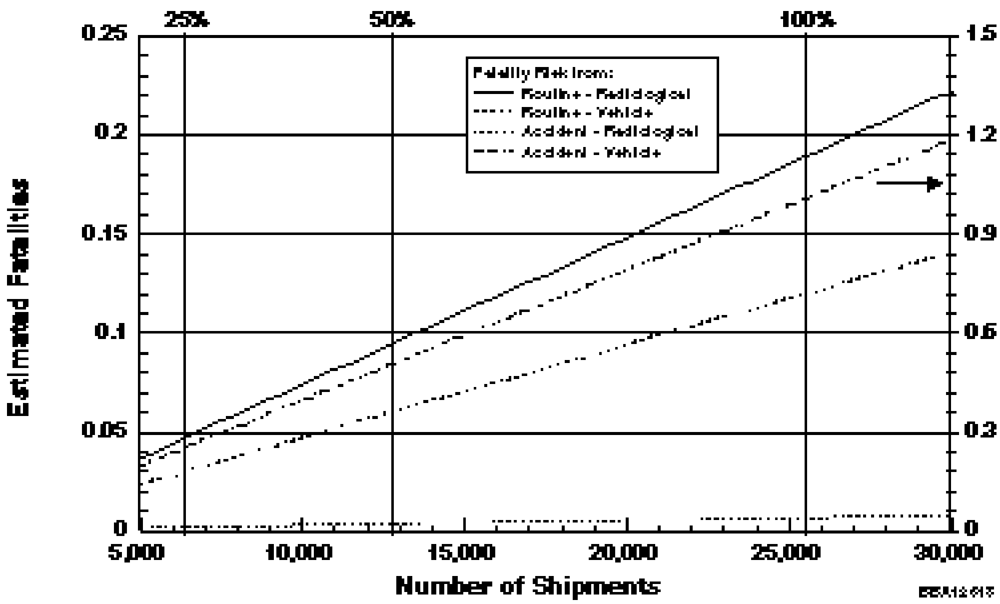

FIGURE K.87 Estimated Truck Transportation Risks for U_3O_8 Shipped from the Conversion Facility to Disposal

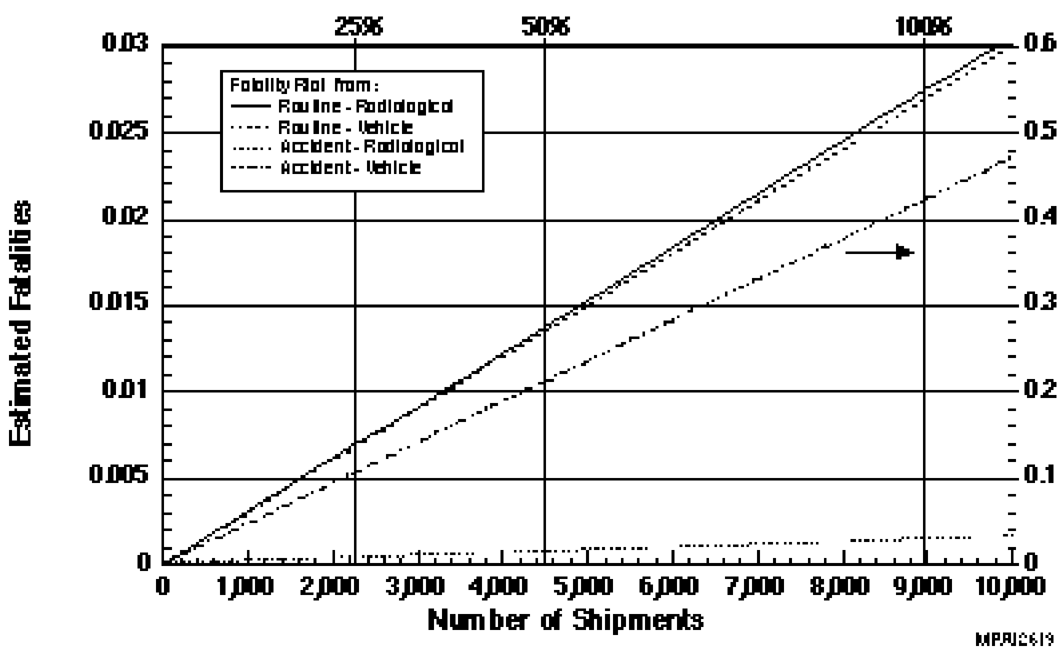

FIGURE K.88 Estimated Rail Transportation Risks for U_3O_8 Shipped from the Conversion Facility to Disposal

TABLE K.6 Example Combinations of Alternatives (Cases) for Which Environmental Impacts Were Evaluated

	Fraction of Inventory		
Case	Use as Uranium Oxide	Use as Uranium Metal	Continued Storage as UF_6 (No Action Alternative)
1	0.25	0.25	0.5
2	0.33	0.33	0.33
3	0.5	0	0.5
4	0	0.5	0.5
5	0.5	0.25	0.25
6	0.25	0.5	0.25
7	0.5	0.5	0

site would be different and the future facilities were assumed to be built at separate sites (except for the continued storage and cylinder preparation activities, which were assumed to occur at the current storage sites; and the conversion and cylinder treatment activities, which would likely occur at the same sites). The potential impacts from continued cylinder storage and cylinder preparation are provided in Appendices D and E, respectively; impacts from the other components are provided in Sections K.1 through K.6.

K.7.1.1 Human Health — Normal Operations

K.7.1.1.1 Radiological Impacts

Involved Workers. The collective radiation dose to involved workers was estimated by summing the radiation dose from each of the components comprising Case 1. The calculation of radiological impacts to involved workers is outlined below. The impacts are first presented for each of the individual components and then summed, as appropriate, to provide an estimate of the total radiological impact.

Continued Cylinder Storage. Potential radiological impacts during continued cylinder storage at the three current storage sites include impacts during storage of 100% of the inventory for a period of 10 years, removal of 50% of the cylinder inventory over a period assumed to be 20 years, and storage of 50% of the inventory for the remaining 10 years considered during the assessment period (1999 through 2039).

The total dose to involved workers was calculated as follows:

Annual dose to involved workers from storage of the entire cylinder inventory
(from Table D.2) = 36 person-rem/yr

Average annual dose from storage of 50% of the entire inventory
= 0.5 × 36 person-rem/yr = 18 person-rem/yr

Average annual dose during the cylinder removal period for removal of 50% of the inventory
= 0.5 × (36 person-rem/yr + 18 person-rem/yr) = 27 person-rem/yr

The total worker dose from continued cylinder storage of 50% of the inventory was then calculated as:

Total worker dose = 10 years × 36 person-rem/yr + 20 years × 27 person-rem/yr
+ 10 years × 18 person-rem/yr

Total worker dose = 1,080 person-rem

Cylinder Preparation. For purposes of assessing Case 1, it was assumed that the 50% of the cylinder inventory converted for use would be transported to a conversion site from the three current storage sites and that all of the cylinders transported would require preparation by either placement in overcontainers or transfer to new cylinders. Shipment of 50% of the cylinder inventory over a 20-year period corresponds to annual rates of 709 cylinders per year at the Paducah site, 335 cylinders per year at the Portsmouth site, and 117 cylinders per year at the K-25 site.

The annual collective dose to workers for a range of shipment rates at each site are provided in Appendix E, Figure E.3, for the overcontainer option and in Figure E.4 for the transfer facility option. The doses corresponding to the above shipment rates are as follows:

Annual dose to workers using overcontainer option = 14 person-rem/yr (Paducah)
+ 6 person-rem/yr (Portsmouth) + 2 person-rem/yr (K-25) = 22 person-rem/yr

Total dose over 20 years using overcontainer option = 22 person-rem/yr × 20 years
= 440 person-rem

Annual dose to workers using cylinder transfer option = 35 person-rem/yr (Paducah)
+ 25 person-rem/yr (Portsmouth) + 20 person-rem/yr (K-25) = 80 person-rem/yr

Total dose over 20 years using cylinder transfer option = 80 person-rem/yr × 20 years
= 1,600 person-rem

Total range of worker dose from cylinder preparation = 440 to 1,600 person-rem

Conversion. The doses to workers from conversion for various throughput rates are provided in Figure K.11 for conversion to uranium oxide (UO_2) and in Figure K.17 for conversion to uranium metal. From these data, the estimated collective worker doses for conversion of 25% of the inventory to oxide and 25% to uranium metal are as follows:

Annual dose to workers from conversion of 25% of the inventory to oxide
= 22 to 31 person-rem/yr

Total worker dose from conversion to oxide = (22 to 31) person-rem/yr
× 20 years = 440 to 620 person-rem

Annual dose to workers from conversion of 25% of the inventory to metal
= 18 to 50 person-rem/yr

Total worker dose from conversion to metal = (18 to 50) person-rem/yr
× 20 years = 360 to 1,000 person-rem

Cylinder Treatment. The collective dose to workers from the treatment of empty cylinders for a range in the number of cylinders treated is provided in Figure K.23. It was assumed that two treatment facilities would be required, one for each conversion facility. On this basis, the estimated doses to workers are as follows:

Annual dose to workers from treatment of 25% of the cylinder inventory
= 6 person-rem/yr

Total worker dose from cylinder treatment = 2 × 6 person-rem/yr
× 20 years = 240 person-rem

Manufacture and Use. The doses to workers from manufacture and use for various throughput rates are provided in Figure K.41 for manufacture of uranium oxide (UO_2) shielded casks and in Figure K.47 for manufacture of uranium metal shielded casks. From these data, the estimated worker doses for manufacture of 25% of the inventory to oxide shielded casks and 25% to uranium metal shielded casks are as follows:

Annual dose to workers from manufacture of 25% of the inventory to oxide casks
= 10 person-rem/yr

Total worker dose from manufacture of oxide casks
= 10 person-rem/yr × 20 years = 200 person-rem

Annual dose to workers from manufacture of 25% of the inventory to metal casks
= 2 person-rem/yr

Total worker dose from manufacture of metal casks
= 2 person-rem/yr × 20 years = 40 person-rem

Total Radiological Impacts to Workers. The total collective radiation dose to involved workers was calculated by summing the collective doses from the individual components. The individual contributions, as well as the total dose, are summarized in Table K.7. In addition, the number of radiation-induced health effects was estimated by multiplying the collective dose by a health risk conversion factor of 4×10^{-4} LCF/person-rem for involved workers. The total LCFs among workers were estimated to range from 1 to 2 over the duration of the program. The radiological impacts to noninvolved workers would be negligible compared to those for involved workers (based on total doses for individual component activities two or more orders of magnitude lower than those for involved workers).

General Public. The collective radiation dose to members of the general public was calculated in a manner similar to that outlined above for workers. However, because the collective dose to members of the public in the vicinity of all sites was found to be well below levels expected to cause adverse health effects for all individual components, a conservative approach was taken to estimate the total impacts. The total impacts to members of the general public were conservatively estimated by summing the maximum dose estimates (100% cases) for each component, as follows:

Maximum collective dose to public from continued cylinder storage (Table D.1)
= 1.1 person-rem

Maximum collective dose to public from cylinder preparation (Table E.1)
= 0.006 person-rem

TABLE K.7 Range of Radiological Doses and Latent Cancer Fatalities among Involved Workers for Case 1: 50% Continued Storage, 25% Use as Oxide, and 25% Use as Metal

Component	Collective Dose (person-rem)
Continued cylinder storage	1,080
Cylinder preparation	440 – 1,600
Oxide conversion	440 – 620
Metal conversion	360 – 1,000
Cylinder treatment	240
Manufacture of oxide casks	200
Manufacture of metal casks	40
Total dose	2,800 – 4,780
Latent cancer fatalities[a]	1 – 2

[a] The number of latent cancer fatalities was calculated using a health risk conversion factor of 4×10^{-4} LCF/person-rem for workers.

Maximum collective dose to public from conversion to oxide (Table F.2)
= 10 person-rem

Maximum collective dose to public from conversion to metal (Table F.2)
= 8 person-rem

Maximum collective dose to public from cylinder treatment (Table F.2)
= 0.008 person-rem

Maximum collective dose to public from manufacture of oxide casks (Table H.1)
= 0.1 person-rem

Maximum collective dose to public from manufacture of metal casks (Table H.1)
= 0.7 person-rem

The maximum total collective dose to the public is estimated to be approximately 20 person-rem, much less than levels expected to cause adverse health effects.

Because individual activities would occur at separate sites and the results of the parametric analyses indicate that impacts decrease with a decrease in the amount processed, the dose to general public MEIs from Case 1 (as well as any of the other combinations analyzed) would be less than the estimates presented for each of the individual components. Therefore, all doses to individual members of the general public would be well below regulatory limits and well below levels expected to cause adverse health effects.

K.7.1.1.2 Chemical Impacts

Chemical impacts from components comprising Case 1 are generally nonadditive because these impacts were estimated for MEIs at each site and future facilities were assumed to be built at separate sites. The two exceptions are (1) continued storage and cylinder preparation activities, which would take place at the current storage sites; and (2) conversion and cylinder treatment activities, which would likely occur at the same site.

Estimated hazard indices for MEIs for all management options are much less than 1 (a hazard index of greater than 1 indicates the potential for health impacts). To provide a conservative estimate of potential hazards from activities occurring at the same sites, the maximum hazard index for both workers and the general public from continued cylinder storage activities for 1999 through 2039 (0.065; Tables D.5 and D.25) was added to the maximum hazard index from cylinder preparation activities (6.1×10^{-6}; Section E.3.1.2). Similarly, the maximum hazard index from conversion options (1.5×10^{-4}; Table F.6) was added to the maximum hazard index from cylinder treatment (7.1×10^{-8}; Table F.6). The results in both cases are still much lower than 1, so adverse chemical impacts from normal operations would not be associated with Case 1 (or any of the other combinations analyzed).

K.7.1.2 Human Health — Accident Conditions

K.7.1.2.1 Radiological and Chemical Impacts

For any combination involving continued cylinder storage and use as oxide and metal, the bounding impacts from accidents involving radiological or chemical releases would be the largest of the impacts estimated for the no action (continued storage) alternative, the use as oxide alternative, or the use as metal alternative. The consequences of bounding accidents for combination alternatives would be the same as the largest consequences of accidents under these alternatives because only a limited amount of material would be at risk of release under accident conditions, regardless of the facility size or throughput. Although the frequencies of some accidents (for example, cylinder-handling accidents) would decrease somewhat as the facility throughput decreased, the overall frequency category for those accidents would remain the same despite these small changes in frequencies.

K.7.1.2.2 Physical Hazards

Physical hazards to involved and noninvolved workers were estimated by summing the injury and fatality hazards from each of the components comprising the combination, similar to the method described for estimating collective worker radiation dose in Section K.7.1.1.1. For Case 1, the calculations to estimate physical hazards are outlined below.

Continued Cylinder Storage. The numbers of fatalities and injuries during continued cylinder storage at the three current storage sites were estimated by summing the numbers estimated for 10 years of storage of the entire inventory, 20 years for removal of 50% of the cylinder inventory, and 10 additional years for storage of the remaining 50% of the inventory (covering the assessment period 1999 through 2039). The total number of fatalities and injuries to workers was calculated as follows:

Annual fatalities during storage of 100% of the inventory (no action) (from Table D.1)
= 0.11/40 years = 0.0028 fatalities per year

Annual injuries during storage of 100% of the inventory (from Table D.1)
= 143/40 years = 3.6 injuries per year

Annual fatalities during storage of 50% of the inventory
= 0.5 × 0.0028 = 0.0014 fatalities per year

Annual injuries during storage of 50% of the inventory
= 0.5 × 3.6 = 1.8 injuries per year

Average annual fatalities during the removal of 50% of the inventory
= 0.5 × (0.0028 fatalities per year + 0.0014 fatalities per year)
= 0.0021 fatalities per year

Average annual injuries during the removal of 50% of the inventory
= 0.5 × (3.6 injuries per year + 1.8 injuries per year)
= 2.7 injuries per year

The total number of fatalities and injuries from continued storage of 50% of the inventory was calculated as follows:

Total fatalities = 10 years × 0.0028 fatalities per year + 20 years × 0.0021 fatalities per year + 10 years × 0.0014 fatalities per year = 0.08 fatalities

Total injuries = 10 years × 3.6 injuries per year + 20 years × 2.7 injuries per year + 10 years × 1.8 injuries per year = 108 injuries

Cylinder Preparation. For purposes of assessing Case 1, it was assumed that the 50% of the cylinder inventory converted for use would be transported to a conversion site from the three current storage sites and that all of the cylinders transported would require preparation by either placement in overcontainers or transfer to new cylinders. Shipment of 50% of the cylinder inventory over a 20-year period corresponds to annual rates of 709 cylinders per year at the Paducah site, 335 cylinders per year at the Portsmouth site, and 117 cylinders per year at the K-25 site.

The fatalities and injuries for workers conducting overcontainer operations are provided in Appendix E, Figure E.10; the fatalities and injuries for workers conducting transfer operations are provided in Figures E.11 and E.12. These data are estimates of the total fatalities and injuries over the entire 20-year period that cylinder preparation activities were assumed to be ongoing. The estimated number of fatalities and injuries corresponding to shipment of 50% of the inventory at each site are as follows:

Fatalities among workers conducting overcontainer operations = 0.043 (Paducah) + 0.02 (Portsmouth) + 0.007 (K-25) = 0.07 fatalities

Injuries among workers conducting overcontainer operations = 57 (Paducah) + 27 (Portsmouth) + 9 (K-25) = 93 injuries

Fatalities among workers conducting cylinder transfer operations = 0.32 (Paducah) + 0.27 (Portsmouth) + 0.15 (K-25) = 0.74 fatalities

Injuries among workers conducting cylinder transfer operations = 218 (Paducah) + 159 (Portsmouth) + 100 (K-25) = 477 injuries

Total range of fatalities from cylinder preparation option = 0.07 to 0.74 fatalities

Total range of injuries from cylinder preparation option = 93 to 477 injuries

Conversion. The estimated numbers of fatalities and injuries for conversion of various throughput rates are provided in Section K.2.2.3. The estimated numbers of fatalities and injuries from conversion for Case 1 are as follows:

Fatalities among workers from conversion of 25% of the inventory to oxide
= 0.35 to 0.49 fatalities

Injuries among workers from conversion of 25% of the inventory to oxide
= 290 to 430 injuries

Fatalities among workers from conversion of 25% of the inventory to metal
= 0.33 to 0.49 fatalities

Injuries among workers from conversion of 25% of the inventory to metal
= 270 to 450 injuries

Cylinder Treatment. The estimated numbers of fatalities and injuries from the treatment of empty cylinders for a range in the number of cylinders treated is provided in Section K.2.2.3. In the case of conversion to both metal and oxide, two separate conversion facilities with separate cylinder treatment facilities would likely be constructed, so the impacts would be two times the 25% impacts, rather than the impacts for a single 50% capacity treatment facility. The estimated numbers of fatalities and injuries from cylinder treatment for Case 1 are as follows:

Fatalities among workers from treatment of 25% of the cylinder inventory = 0.13 fatalities

Injuries among workers from treatment of 25% of the cylinder inventory = 121 injuries

Total fatalities = 2 × 0.13 = 0.26 fatalities

Total injuries = 2 × 121 = 242 injuries

Manufacture and Use. Fatalities and injuries for manufacture of uranium oxide (UO_2) shielded casks are presented in Figure K.49; values for manufacture of uranium metal shielded casks are presented in Figure K.50. The estimated numbers of fatalities and injuries for Case 1 are as follows:

Fatalities among workers from manufacture of 25% of the inventory to oxide casks
= 0.61 fatalities

Injuries among workers from manufacture of 25% of the inventory to oxide casks
= 490 injuries

Fatalities among workers from manufacture of 25% of the inventory to metal casks
= 0.68 fatalities

Injuries among workers from manufacture of 25% of the inventory to metal casks
= 520 injuries

Total Physical Hazards. The total fatalities and injuries were calculated by summing the values for the individual components and then rounding to the nearest whole number. The individual contributions and total fatalities and injuries are summarized in Table K.8.

K.7.1.3 Transportation

The transportation impacts for normal operations and traffic accident fatalities were determined by the number of shipments required for each combination alternative, assuming a travel distance of 620 miles (1,000 km) per shipment. For Case 1, these impacts would be the sum of the number of shipments if 25% of the inventory was converted for use as oxide and 25% of the inventory was converted for use as metal (no off-site transportation of cylinders would be required

TABLE K.8 Range of On-the-Job Fatalities and Injuries among All Workers for Case 1: 50% Continued Storage, 25% Use as Oxide, and 25% Use as Metal[a]

Component	Fatalities	Injuries
Continued cylinder storage	0.08	110
Cylinder preparation	0.07 – 0.74	93 – 480
Oxide conversion	0.35 – 0.49	290 – 430
Metal conversion	0.33 – 0.49	270 – 450
Cylinder treatment	0.26	240
Manufacture of oxide casks	0.61	490
Manufacture of metal casks	0.68	520
Total	2 – 3	2,000 – 2,700

[a] Represents impacts to involved and noninvolved workers from construction and operation of facilities. Values rounded to two significant figures.

for continued cylinder storage). The impacts of the various combinations examined would be essentially the same for exposures from normal operations because these exposures would generally be expected to result in 1 or fewer adverse health effects among workers and members of the general public combined. As would be expected, traffic accident fatalities for Case 1, which would involve transportation of 50% of the cylinder inventory and the resulting conversion products, are estimated to be about half of those expected under the use as oxide and use as metal alternatives (Table K.9, which follows Section K.7.2 of this appendix).

For any combination involving continued cylinder storage and use as oxide and metal, the bounding impacts for accidents involving releases from cylinders or releases of other materials would be the larger of the impacts estimated for either the use as oxide alternative or the use as metal alternative. The consequences of bounding accidents for combination alternatives would be the same as the largest consequences of these alternatives because the same amount of material would be at risk under accident conditions, regardless of the number of shipments. The overall probability of accidents occurring would decrease in direct proportion to the number of shipments and the distance per shipment; in Case 1, the overall probability would be about half that estimated for the use as oxide alternative.

K.7.1.4 Air Quality

Air quality impacts from construction at the current storage sites would be the same as those predicted for the no action alternative because all construction activities are planned to take place prior to about 2003, during which time all cylinders would remain at the current storage locations under all alternatives and combination alternatives examined.

Air quality impacts from operations at the current storage sites for combination alternatives involving varying percentages of continued storage would depend on whether a certain percentage of cylinders was removed from each site or whether cylinders were preferentially removed from one or two of the sites. For 100% continued storage (no action alternative), a potential impact that could occur if cylinder maintenance and painting activities do not reduce cylinder corrosion rates would be exceedance of the HF standard at the K-25 site in about the year 2020 (see Appendix D, Section D.3, for further discussion).

In examining the potential air quality impacts of combination alternatives, the case where cylinders at the Paducah and Portsmouth sites would be preferentially removed for use was assumed as the bounding case, leaving all cylinders in place at the K-25 site. (The number of cylinders stored at the K-25 site constitutes only about 10% of the entire inventory, so that the combination alternatives that consider from 25 to 75% use of the inventory could all have the entire K-25 inventory remaining in place). Therefore, the bounding air quality impacts from operations at the current storage sites for combination alternatives (including Case 1) would be the same as the impacts from the no action alternative. If the cylinders at K-25 were preferentially removed or part of the inventory was removed, then air quality impacts at the K-25 site would decrease accordingly. Also, if continued maintenance and painting are effective in controlling cylinder corrosion, as expected, concentrations of HF would be kept within regulatory standards at all sites under all combination alternatives.

Pollutant emissions during construction and operation of conversion and manufacturing facilities designed to process the entire inventory would remain within standards. Emissions under the combination alternatives also would remain within standards because emissions were estimated to be within applicable standards for full-scale (100%) facilities and emissions would be somewhat reduced for facilities with lower throughput rates because different sites were assumed for new facilities.

K.7.1.5 Water and Soil

As discussed for air quality impacts, impacts to groundwater at the current storage sites for combination alternatives involving varying percentages of continued storage would depend on whether a certain percentage of cylinders was removed from each site or whether cylinders were preferentially removed from one or two of the sites. For the no action alternative, a potential impact that could occur if cylinder maintenance and painting activities do not reduce cylinder corrosion rates would be that the groundwater uranium concentration at all three sites could exceed 20 µg/L in about the year 2100 or later (see Appendix D, Section D.3, for further discussion). For combination alternatives, the case where cylinders at the Paducah and Portsmouth sites would be preferentially removed for use was assumed as the bounding case, leaving all cylinders in place at the K-25 site. Therefore, the bounding groundwater quality impacts at the current storage sites for combination alternatives could include exceedance of the 20 µg/L guideline level at one or more of the current storage sites at some time after the year 2100. However, if cylinder maintenance and painting are effective in controlling cylinder corrosion, as expected, groundwater uranium concentrations would remain below 20 µg/L at all sites.

Potential surface water, groundwater and soil quality impacts at conversion and manufacturing facilities could be kept within applicable standards or guidelines by following good engineering practices.

K.7.1.6 Socioeconomics

Socioeconomic impacts for each component of the combination alternatives are summarized in Tables K.9 and K.10 (which follow Section K.7.2). Methods of estimating these impacts are discussed in Sections K.7.1.6.1 and K.7.1.6.2.

K.7.1.6.1 Continued Cylinder Storage

Socioeconomic impacts from construction activities at the current storage sites would be the same as those predicted for the no action alternative because all construction activities are planned to take place prior to about 2003, during which time all cylinders would remain at the current storage locations under all alternatives and combination alternatives examined.

The socioeconomic analysis evaluated direct income and jobs for the first year of operations. These values may be interpreted as annual averages over the operational periods because annual operations would generally be uniform. Continued storage impacts for combination alternatives need to be normalized to a standard number of years because continued storage would be ongoing for about 40 years (1999 through 2039), whereas use options were assumed to be ongoing for only 20 years (2009 through 2028). For continued storage operations, the totals for direct jobs and direct income were calculated as follows:

Direct jobs during storage (no action), three-site total (from Table D.18)
= 110 jobs per year

Direct income during storage, three-site total (from Table D.18)
= \$5.1 million per year

Direct jobs during cylinder removal (action alternatives), three-site total (from Table D.30)
= 120 jobs per year

Direct income during cylinder removal, three-site total (from Table D.30)
= \$6 million per year

Average jobs during the removal of 50% of the inventory = 0.5 × (110 jobs per year
+ 120 jobs per year) = 115 jobs per year

Average income during the removal of 50% of the inventory = 0.5 × (\$5.1 million/yr
+ \$6 million per year) = \$5.55 million per year

The total jobs and income from continued storage of 50% of the inventory was calculated as follows:

Total jobs = 10 years × 110 jobs per year + 20 years × 115 jobs per year
+ 10 years × 55 jobs per year = 3,950 job-years

Total income = 10 years × \$5.1 million per year + 20 years × \$5.55 million per year
+ 10 years × \$2.55 million per year) = \$187.5 million

To facilitate comparison with the no action alternative, the total jobs and income were distributed over 40 years, resulting in a value of 99 jobs per year and $4.7 million income per year over 40 years (see Table K.9). To compare with use alternatives, the values should be converted to total jobs, assuming 40 years for no action and combination alternatives involving continued storage, and assuming 20 years for alternatives involving use only.

K.7.1.6.2 Cylinder Preparation, Conversion, and Manufacturing

Parametric socioeconomic impacts for the cylinder preparation, conversion, and manufacturing options were assessed qualitatively (see Sections E.3.5, K.2.5, and K.4.5), based on preliminary cost data for the 100% cases (LLNL 1996) and socioeconomic data for parametric cases provided in the cost analysis report (LLNL 1997b). The estimated direct jobs and direct employment values for combination alternatives calculated using the above-described data are presented in Tables K.9 and K.10.

K.7.1.7 Ecology

The principal differences in ecological impacts between the combination alternatives would be associated with habitat loss. Potential habitat loss at the current storage sites is the sum of habitat loss that would occur under the no action alternative (7 acres [2.8 ha]), which would be applicable for all alternatives because construction would occur prior to 2003) and loss that would occur from cylinder preparation activities. If overcontainers were used, no additional habitat loss would occur. Transfer facilities would range in areal site requirements from about 12 acres (4.9 ha) for a facility to process the inventory at the K-25 site (10% of the entire inventory), to 14 acres (5.7 ha) for a facility to process the inventory at the Portsmouth site (30% of the entire inventory), to 21 acres (8.5 ha) for a facility to process the inventory at the Paducah site (60% of the entire inventory) (see Section E.3.6). For alternatives involving 100% use, the maximum habitat loss at any site would be 28 acres (21 + 7) (11 ha). To estimate habitat loss for alternatives involving 50 to 75% use, it was assumed that all cylinders would be taken from a single facility until the entire inventory at a single site was used. Therefore, maximum habitat loss at any site for a 50% use facility would be estimated at 21 acres (8.5 ha) (Paducah site value) + 7 acres (2.8 ha), or 28 acres (11 ha). Similarly, maximum habitat loss at any site for alternatives involving 75% use would also be 28 acres (11 ha).

Potential habitat loss for conversion facilities was calculated on the basis of data provided in Sections K.2.9.2, K.2.9.3, and K.2.9.4. The habitat losses corresponding to 25%, 50% and 100% capacity uranium oxide (UO_2) conversion facilities would be 16, 19, and 24 acres (6.5, 7.7, and 9.7 ha), respectively. Similarly, the habitat losses corresponding to 25%, 50% and 100% capacity metal conversion facilities would be 17, 21, and 26 acres (6.9, 8.5, and 10.5 ha), respectively. Finally, for 25%, 50%, and 100% cylinder treatment facilities, the habitat losses would be 7, 8, and 9 acres

(2.8, 3.2, and 3.6 ha), respectively. Although these parametric values were calculated for specific conversion options (e.g., conversion to UO_2 by the dry process, with anhydrous HF production), the amount of land required for the other conversion technologies would be roughly similar. For combination options involving both oxide and metal conversion, two cylinder treatment facilities would be required, one for each conversion facility. The habitat loss for conversion for Case 1 (25% use as oxide, 25% use as metal) was calculated as follows:

Habitat loss for conversion to oxide = 16 acres (6.5 ha)

Habitat loss for conversion to metal = 17 acres (6.9 ha)

Habitat loss for a treatment facility = 7 acres (2.8 ha)

Habitat loss for each conversion facility = 23 to 24 acres (9.3 to 9.7 ha) (total of 47 acres)

Potential habitat loss for manufacturing facilities was calculated on the basis of data given in Section K.4.9. For an oxide cask manufacturing facility, the land areas corresponding to 25%, 50%, and 100% capacity would be 79, 84, and 90 acres (32, 34, and 36 ha), respectively; the land areas for 25%, 50% and 100% capacity at a metal cask manufacturing facility are assumed to be the same. For Case 1, two 25% capacity manufacturing facilities would be required, so the total land area would be about 79 acres (32 ha) at either manufacturing facility (total of 158 acres).

K.7.1.8 Waste Management

For waste management at the current storage sites, impacts for all combination alternatives would be similar to those estimated for the no action alternative. Although waste generation amounts would vary somewhat on the basis of the numbers of cylinders being stored and maintained, overall impacts to nationwide waste generation would be negligible. Waste generation impacts associated with waste management capabilities at the Portsmouth and K-25 sites would be negligible. Due to large amounts of cylinder painting assumed at the Paducah site in the earlier years of continued storage, impacts to LLMW management at the Paducah site would be moderate for all combination alternatives.

The use as oxide and use as metal alternatives have potential moderate impacts to nationwide LLW generation on the basis of a possible requirement to dispose of CaF_2 and/or MgF_2 as LLW, if the CaF_2 or MgF_2 were considered DOE waste. If such disposal were required, these alternatives could generate a volume of LLW equal to about 10% of the projected DOE complexwide disposal volume. Moderate impacts to nationwide waste management are defined as additional volumes in excess of 10% of the DOE complexwide disposal volume; negligible to low impacts generate less than 10%. Assuming a linear decrease in potential LLW production, combination alternatives involving 50% or more conversion to oxide or metal could have low to moderate impacts on nationwide LLW waste management.

K.7.1.9 Resource Requirements

Under the combination alternatives, adverse effects on local, regional, or national availability of materials would not be expected.

K.7.1.10 Land Use

Land use corresponds to habitat loss. See Section K.7.1.7 for an explanation of the values calculated for the combination alternatives.

K.7.1.11 Other Areas of Impact

Impacts to cultural resources at the current storage sites would depend on the selected locations for construction activities but are considered unlikely. Cultural resource activities at other facilities would depend on the locations and will be examined in detail at the next stage of the program when facilities are actually sited. Adverse environmental justice impacts for activities occurring under the example combination alternatives are not expected. The occurrence of severe transportation accidents involving a release is unlikely, and accidents occur at random locations along transportation corridors; therefore, significant and disproportionate high and adverse impacts to minority or low-income populations are unlikely.

K.7.2 Summary of Impacts for Example Combination Alternatives

The method used to estimate the impacts for combination alternatives described in Section K.7.1 was used to evaluate the impacts for the example cases listed in Table K.6. The results for the first six cases analyzed are presented in detail in Table K.9. The results for an additional 50% use as oxide, 50% use as metal combination strategy are presented in Table K.10. In general, the impacts for these combination alternatives tend to be very similar to the impacts estimated for the primary alternatives evaluated in the PEIS (as summarized in Chapter 2, Table 2.2).

TABLE K.9 Summary Comparison of Environmental Consequences of Example Combinations of Use as Oxide, Use as Metal, and Continued Storage as UF_6 Alternatives

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
Human Health and Safety — Normal Facility Operations [a]						
Radiation Exposure						
Involved workers						
Annual dose to individual workers	Monitored to be maintained within maximum regulatory limit of 5 rem/yr or lower	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total health effects among involved workers (1999-2039)	1 to 2 additional LCFs	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Noninvolved workers						
Annual dose to noninvolved worker MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total health effects among noninvolved workers (1999-2039)	0 additional LCFs from routine site emissions	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
General public						
Annual dose to general public MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total health effects among members of the public (1999-2039)	0 additional LCFs from routine site emissions	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Chemical Exposure of Concern (Concern = hazard index > 1)						
Noninvolved worker MEI [b]	No (Hazard Index <1)	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
General public MEI	No (Hazard Index <1)	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
Human Health and Safety — Facility Accidents[a]						
Physical Hazards from Construction and Operations (involved and noninvolved workers)						
On-the-job fatalities and injuries (1999-2039)	2-3 fatalities; 2,000-2,700 injuries	2-3 fatalities; 2,100-2,800 injuries	1-2 fatalities; 1,200-1,700 injuries	1-2 fatalities; 1,200-1,800 injuries	3-4 fatalities; 2,200-2,900 injuries	3-4 fatalities; 2,100-2,900 injuries
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites						
Likely Cylinder Accidents[c]						
Accident[d]	Corroded cylinder spill, dry conditions	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Release	Uranium, HF	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Estimated frequency	~ 1 in 10 years	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident probability (1999-2039)	3-4 potential accidents	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Consequences (per accident)						
Chemical exposure – public	No adverse effects	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Chemical exposure – noninvolved workers[e]						
Adverse effects	70	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Irreversible adverse effects	3	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Radiation exposure – public						
Dose to MEI	3 mrem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Risk of LCF	1 in 1 million	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total dose to population	0.4 person-rem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total LCFs	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Radiation exposure – noninvolved workers[e]						
Dose to MEI	77 mrem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Risk of LCF	3 in 100,000	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total dose to workers	2.2 person-rem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total LCFs	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident risk (consequence times probability)						
General public	0 fatalities	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Workers	0 fatalities	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
Human Health and Safety — Facility Accidents[a] (Cont.)						
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites (Cont.)						
Low Frequency-High Consequence Cylinder Accidents[f]						
Accidents[d]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Release	Uranium, HF	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Estimated frequency	~ 1 in 100,000 years	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident probability (1999-2039)	~ 1 chance in 2,500	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Consequences (per accident)						
Chemical exposure – public						
Adverse effects	1,900	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Irreversible adverse effects	1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Chemical exposure – noninvolved workers[e]						
Adverse effects	1,000	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Irreversible adverse effects	300	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	3	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Radiation exposure – public						
Dose to MEI	15 mrem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Risk of LCF	7 in 1 million	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total dose to population	1 person-rem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total LCFs	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Radiation exposure – noninvolved workers[e]						
Dose to MEI	20 mrem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Risk of LCF	8 in 1 million	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total dose to workers	16 person-rem	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Total LCFs	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident risk (consequence times probability)						
General public	0 fatalities	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Noninvolved workers	0 fatalities	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
Human Health and Safety — Facility Accidents[a] (Cont.)						
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[f]						
Chemical accident[d]	HF or NH_3 tank rupture	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Release	HF, NH_3	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident location	Conversion site	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Estimated frequency	< 1 in 1 million years	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident probability (1999-2039)	1 chance in 50,000	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Consequences (per accident)						
Chemical exposure – public						
Adverse effects	41,000	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Irreversible adverse effects	1,700	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	30	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Chemical exposure – noninvolved workers[e]						
Adverse effects	1,100	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Irreversible adverse effects	440	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	4	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident risk (consequence times probability)						
General public	0 fatalities	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Noninvolved workers[e]	0 fatalities	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Radiological accident[d]	Earthquake damage to storage building at conversion site	Same as Case 1	Same as Case 1	Vehicle-induced fire, 3 full cylinders	Same as Case 1	Same as Case 1
Release	Uranium (UO_2)	Same as Case 1	Same as Case 1	Uranium	Same as Case 1	Same as Case 1
Accident location	Conversion site	Same as Case 1	Same as Case 1	Conversion site	Same as Case 1	Same as Case 1
Estimated frequency	1 in 100,000 years	Same as Case 1	Same as Case 1	1 in 100,000 years	Same as Case 1	Same as Case 1
Accident probability (1999-2039)	1 chance in 5,000	Same as Case 1	Same as Case 1	1 chance in 5,000 (over 20 years)	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
Human Health and Safety — Facility Accidents[a] (Cont.)						
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[f] (Cont.)						
Consequences (per accident)						
Radiation exposure – public						
Dose to MEI	68 mrem	Same as Case 1	Same as Case 1	15 mrem	Same as Case 1	Same as Case 1
Risk of LCF	3 in 100,000	Same as Case 1	Same as Case 1	7 in 1 million	Same as Case 1	Same as Case 1
Total dose to population	5.1 person-rem	Same as Case 1	Same as Case 1	56 person-rem	Same as Case 1	Same as Case 1
Total LCFs	0	Same as Case 1	Same as Case 1	0	Same as Case 1	Same as Case 1
Radiation exposure – noninvolved workers[e]						
Dose to MEI	2,300 mrem	Same as Case 1	Same as Case 1	20 mrem	Same as Case 1	Same as Case 1
Risk of LCF	9 in 10,000	Same as Case 1	Same as Case 1	8 in 1 million	Same as Case 1	Same as Case 1
Total dose to workers	210 person-rem	Same as Case 1	Same as Case 1	8 person-rem	Same as Case 1	Same as Case 1
Total LCFs	0	Same as Case 1	Same as Case 1	0	Same as Case 1	Same as Case 1
Accident risk (consequence times probability)						
General public	0 LCFs	Same as Case 1	Same as Case 1	0 LCFs	Same as Case 1	Same as Case 1
Noninvolved workers[e]	0 LCFs	Same as Case 1	Same as Case 1	0 LCFs	Same as Case 1	Same as Case 1
Human Health and Safety — Transportation[a]						
Major Materials Assumed to Be Transported between Sites	UF_6 cylinders Uranium oxide Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks	UF_6 cylinders Uranium oxide Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks	UF_6 cylinders Uranium oxide HF (if produced) CaF_2 (if produced) NH_3 LLW/LLMW Casks	UF_6 cylinders Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks	UF_6 cylinders Uranium oxide Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks	UF_6 cylinders Uranium oxide Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
Human Health and Safety — Transportation[a] (Cont.)						
Normal Operations						
Fatalities from exposure to vehicle exhaust and external radiation	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Maximum radiation exposure to a person along a route (MEI)	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem	Less than 0.1 mrem
Traffic Accident Fatalities (1999-2039) (physical hazards, unrelated to cargo)						
Maximum use of trucks	2 fatalities	3 fatalities	2 fatalities	2 fatalities	3 fatalities	3 fatalities
Maximum use of rail	1 fatality	1 fatality	1 fatality	1 fatality	1 fatality	1 fatality
Traffic Accidents Involving Releases of Radiation or Chemicals						
Low Frequency-High Consequence Cylinder Accidents						
Accident	Urban rail accident involving 4 cylinders	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Release	Uranium, HF	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident probability (1999-2039)	1 chance in 10,000	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Consequences (per accident)						
Chemical exposure – All workers and members of general public						
Irreversible adverse effects	4	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Radiation exposure – All workers and members of general public						
Total LCFs	60	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident risk (consequence times probability) – Workers and general public	0 fatalities	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
Human Health and Safety — Transportation[a] (Cont.)						
Traffic Accidents Involving Releases of Radiation or Chemicals (Cont.)						
Low Frequency-High Consequence Accidents with All Other Materials						
Accident	Urban rail accident involving anhydrous HF	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Release	Anhydrous HF	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident probability (1999-2039)	1 chance in 30,000	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Consequences (per accident)						
Chemical exposure – All workers and members of general public						
Irreversible adverse effects	30,000	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	300	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Accident risk (consequence times probability)						
Irreversible adverse effects	1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Fatalities	0	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Air Quality			
Current Storage Sites						
Pollutant emissions during construction	Maximum 24-hour PM_{10} concentration up to 95% of standard; other criteria pollutants well within standards	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Pollutant emissions during operations	Maximum 24-hour HF concentration up to 23% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other Facilities[g]						
Pollutant emissions during construction and operations	Maximum 24-hour PM_{10} concentration up to 90% of standard; other pollutant emissions well within standards (all less than 30% of standards)	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
Water and Soil [h]						
Current Storage Sites						
Surface water, groundwater, and soil quality	Uranium concentrations would remain within guideline levels	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other parameters[i]	No change	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other Facilities[g]						
Surface water, groundwater, and soil quality	Site-dependent; contaminant concentrations could be kept within guideline levels	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other parameters[i]	Site-dependent; none to moderate impacts	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Excavation of Soil for Long-Term Storage or Disposal	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Socioeconomics [j]						
Current Storage Sites						
Continued storage	**Jobs:** 30 peak year, construction; 99 per year over 40 years, operations	**Jobs:** 30 peak year, construction; 94 per year over 40 years, operations	**Jobs:** 30 peak year, construction; 99 per year over 40 years, operations	**Jobs:** 30 peak year, construction; 99 per year over 40 years, operations	**Jobs:** 30 peak year, construction; 93 per year over 40 years, operations	**Jobs:** 30 peak year, construction; 93 per year over 40 years, operations
	Income: $1.4 million peak year, construction; $4.7 million per year over 40 years, operations	**Income:** $1.4 million peak year, construction; $4.5 million per year over 40 years, operations	**Income:** $1.4 million peak year, construction; $4.7 million per year over 40 years, operations	**Income:** $1.4 million peak year, construction; $4.7 million per year over 40 years, operations	**Income:** $1.4 million peak year, construction; $4.5 million per year over 40 years, operations	**Income:** $1.4 million peak year, construction; $4.5 million per year over 40 years, operations

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Socioeconomics[j] (Cont.)			
Current Storage Sites (Cont.)						
Cylinder preparation	**Jobs:** 0-290 peak year, preoperations; 150-250 per year over 20 years operations	**Jobs:** 0-380 peak year, preoperations; 200-320 per year over 20 years, operations	**Jobs:** 0-290 peak year, preoperations; 150-250 per year over 20 years, operations	**Jobs:** 0-290 peak year, preoperations; 150-250 per year over 20 years, operations	**Jobs:** 0-440 peak year, preoperations; 230-370 per year over 20 years, operations	**Jobs:** 0-440 peak year, preoperations; 230-370 per year over 20 years, operations
	Income: $0-13 million peak year, preoperations; $10-13 million per year over 20 years, operations	**Income:** $0-17 million peak year, preoperations; $13-17 million per year over 20 years, operations	**Income:** $0-13 million peak year, preoperations; $10-13 million per year over 20 years, operations	**Income:** $0-13 million peak year, preoperations; $10-13 million per year over 20 years, operations	**Income:** $0-20 million peak year, preoperations; $14-19 million per year over 20 years, operations	**Income:** $0-20 million peak year, preoperations; $14-19 million per year over 20 years, operations
Other Facilities[g]						
Conversion	**Jobs:** 620-960 peak year, construction; 490-720 per year over 20 years, operations	**Jobs:** 670-1,030 peak year, construction; 500-750 per year over 20 years, operations	**Jobs:** 290-630 peak year, construction; 250-380 per year over 20 years, operations	**Jobs:** 420-470 peak year, construction; 270-400 per year over 20 years, operations	**Jobs:** 660-1,000 peak year, construction; 480-710 per year over 20 years, operations	**Jobs:** 670-1,010 peak year, construction; 540-800 per year over 20 years, operations
	Income: $25-41 million peak year, construction; $29-41 million per year over 20 years, operations	**Income:** $27-44 million peak year, construction; $30-42 million per year over 20 years, operations	**Income:** $14-28 million peak year, construction; $15-22 million per year over 20 years, operations	**Income:** $15-18 million peak year, construction; $16-22 million per year over 20 years, operations	**Income:** $27-45 million peak year, construction; $29-40 million per year over 20 years, operations	**Income:** $26-43 million peak year, construction; $31-44 million per year over 20 years, operations

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Socioeconomics[j] (Cont.)			
Other Facilities[g] (Cont.)						
Long-term storage	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Manufacturing	**Jobs:** 270 peak year, construction; 430 per year over 20 years, operations	**Jobs:** 280 peak year, construction; 490 per year over 20 years, operations	**Jobs:** 130 peak year, construction; 260 per year over 20 years, operations	**Jobs:** 160 peak year, construction; 290 per year over 20 years, operations	**Jobs:** 280 peak year, construction; 480 per year over 20 years, operations	**Jobs:** 290 peak year, construction, 480 per year over 20 years, operations
	Income: $13 million peak year, construction; $30 million per year over 20 years, operations	**Income:** $13 million peak year, construction; $34 million per year over 20 years, operations	**Income:** $5.8 million peak year, construction; $18 million per year over 20 years, operations	**Income:** $7.7 million peak year, construction; $20 million per year over 20 years, operations	**Income:** $13 million peak year, construction; $33 million per year over 20 years, operations	**Income:** $13 million peak year, construction; $33 million per year over 20 years, operations
Disposal	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Ecology			
Current Storage Sites						
Habitat loss	Up to 28 acres; negligible to potential moderate impacts	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Wetlands and threatened or endangered species	None to negligible impacts	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other Facilities[g]						
Habitat loss[k]	**Conversion:** Up to 24 acres at a single facility, total of 47 acres; potential moderate impacts to vegetation and wildlife	**Conversion:** Up to 30 acres at a single facility, total of 52 acres; potential moderate impacts to vegetation and wildlife	**Conversion:** Up to 27 acres total; potential moderate impacts to vegetation and wildlife	**Conversion:** Up to 29 acres total; potential moderate impacts to vegetation and wildlife	**Conversion:** Up to 27 acres at a single facility, 51 acres total; potential moderate impacts to vegetation and wildlife	**Conversion:** Up to 29 acres at a single facility, 52 acres total; potential moderate impacts to vegetation and wildlife
	Manufacturing: Up to 79 acres at a single facility, total of 158 acres; potential moderate to large impacts to vegetation and wildlife	**Manufacturing:** Up to 81 acres at a single facility, total of 162 acres; potential moderate to large impacts to vegetation and wildlife	**Manufacturing:** Up to 84 acres total; potential moderate impacts to vegetation and wildlife	**Manufacturing:** Up to 84 acres total; potential moderate impacts to vegetation and wildlife	**Manufacturing:** Up to 84 acres at a single facility, 163 acres total; potential moderate to large impacts to vegetation and wildlife	**Manufacturing:** Up to 84 acres at a single facility, 163 acres total; potential moderate to large impacts to vegetation and wildlife
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Wetlands and threatened or endangered species	Site-dependent; avoid or mitigate	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Waste Management			
Current Storage Sites	**LLW:** no impacts **LLMW:** potential moderate impacts with respect to current waste generation at Paducah (> 20%); negligible impacts with respect to Portsmouth, K-25, or nationwide waste generation	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other Facilities[g]						
Conversion	Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) and MgF_2 as LLW (if required); potential moderate impact to site waste generation for CaF_2 and MgF_2 as nonhazardous solid waste	Same as Case 1	Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) as LLW (if required); potential moderate impact to site waste generation for CaF_2 as nonhazardous solid waste	Potential moderate impacts to current nationwide LLW generation for MgF_2 as LLW (if required), potential moderate impact to site waste generation for MgF_2 as nonhazardous solid waste	Same as Case 1	Same as Case 1
Manufacturing	Negligible impacts with respect to current regional or nationwide waste generation	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Resource Requirements [l]			
All Sites	No effects on local, regional, or national availability of materials are expected	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
			Land Use [k]			
Current Storage Sites	Up to 28 acres; less than 1% of available land; negligible impacts	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other Facilities[g]						
Conversion	Up to 24 acres at a single facility, total of 47 acres; negligible impacts	Up to 30 acres at a single facility, total of 52 acres; negligible impacts	Up to 27 acres total; negligible impacts	Up to 29 acres total; negligible impacts	Up to 27 acres at a single facility, 51 acres total; negligible impacts	Up to 29 acres at a single facility, 52 acres total; negligible to potential moderate impacts
Manufacturing	Up to 79 acres at a single facility, total of 158 acres; potential moderate impacts	Up to 81 acres at a single facility, total of 162 acres; potential moderate impacts	Up to 84 acres total; potential moderate impacts	Up to 84 acres total; potential moderate impacts	Up to 84 acres at a single facility, 163 acres total; potential moderate impacts	Up to 84 acres at a single facility, 163 acres total; potential moderate impacts
			Cultural Resources			
Current Storage Sites	Impacts unlikely	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1
Other Facilities[g]	Impacts dependent on location; avoid and mitigate	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

TABLE K.9 (Cont.)

Environmental Consequence	Case 1: 25% Use as Oxide; 25% Use as Metal; 50% Continued Storage	Case 2: 33% Use as Oxide; 33% Use as Metal; 33% Continued Storage	Case 3: 50% Use as Oxide; 50% Continued Storage	Case 4: 50% Use as Metal; 50% Continued Storage	Case 5: 50% Use as Oxide; 25% Use as Metal; 25% Continued Storage	Case 6: 25% Use as Oxide; 50% Use as Metal; 25% Continued Storage
			Environmental Justice			
All Sites	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents; severe transportation accidents are unlikely and occur at random locations along routes; therefore, high and adverse disproportionate impacts to minority or low-income populations are unlikely	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1	Same as Case 1

a For purposes of comparison, estimates of human health effects (e.g., LCFs) have been rounded to the nearest whole number. Accident probabilities are the estimated frequencies multiplied by the number of years of operations.

b Chemical exposures for involved workers during normal operations would depend in part on facility designs. The workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable exposure limits.

c Accidents with probabilities of occurrence greater than 0.01 per year.

d On the basis of calculations performed for the PEIS, the accidents that are listed in this table have been found to have the highest consequences of all the accidents analyzed for the given frequency range. In general, accidents that have lower probabilities have higher consequences.

e In addition to noninvolved worker impacts, chemical and radiological exposures for involved workers under accident conditions (workers within 100 m of a release) would depend in part on facility designs and other factors (see Section 4.3.2.1).

f Accidents with probabilities of occurrence from 0.0001 per year to less than 0.000001 per year.

g Other facilities are facilities for conversion, long-term storage, manufacturing, and disposal.

h The guideline concentration used for comparison with estimated surface water and groundwater uranium concentrations is the proposed EPA maximum contaminant level of 20 µg/L; this value is an applicable standard for water "at the tap" of the user, and is not a directly applicable standard for surface water or groundwater (no such standard exists). The guideline concentration used for comparison with estimated soil uranium concentrations is a health-based guideline value for residential settings of 230 µg/g.

Footnotes continue on next page

TABLE K.9 (Cont.)

Footnotes (Cont.)

[i] Other parameters evaluated include changes in runoff, floodplain encroachment, groundwater recharge, depth to groundwater, direction of groundwater flow, soil permeability, and erosion potential.

[j] For construction, direct jobs and direct income are reported for the peak construction year. For operations, direct jobs and income are presented as annual averages, except for continued storage, which is reported for the peak year of operations.

[k] Habitat losses and land-use acreages given as maximum for a single site or facility, conversion facilities would also need to establish protective action distances encompassing 960 acres around the facility.

[l] Resources evaluated include construction materials (e.g., concrete, steel, special coatings), fuel, electricity, process chemicals, and containers (e.g., drums and cylinders).

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MEI = maximally exposed individual; MgF_2 = magnesium fluoride; NH_3 = ammonia; UF_6 = uranium hexafluoride.

TABLE K.10 Summary of Potential Environmental Consequences of Example 50% Use as Oxide, 50% Use as Metal Combination Alternative

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
Human Health and Safety — Normal Facility Operations[a]	
Radiation Exposure	
Involved workers	
Annual dose to individual workers	Monitored to be maintained within maximum regulatory limit of 5 rem/yr or lower
Total health effects among involved workers (1999–2039)	1 to 2 additional LCFs
Noninvolved workers	
Annual dose to noninvolved worker MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)
Total health effects among noninvolved workers (1999–2039)	0 additional LCFs from routine site emissions
General public	
Annual dose to general public MEI (all facilities)	Well within public health standards (i.e., less than maximum dose limit of 100 mrem/yr)
Total health effects among members of the public (1999–2039)	0 additional LCFs from routine site emissions
Chemical Exposure of Concern (concern = hazard index > 1)	
Noninvolved worker MEI[b]	No (Hazard Index <1)
General public MEI	No (Hazard Index <1)
Human Health and Safety — Facility Accidents[a]	
Physical Hazards from Construction and Operations (involved and noninvolved workers)	
On-the-job fatalities and injuries (1999–2039)	3–4 fatalities; 2,300–3,100 injuries
Accidents Involving Releases of Chemicals or Radiation: Cylinder Accidents at Current Storage Sites	
Likely Cylinder Accidents[c]	
Accident[d]	Corroded cylinder spill, dry conditions
Release	Uranium, HF
Estimated frequency	~ 1 in 10 years
Accident probability (1999–2039)	3 potential accidents

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
Human Health and Safety — Facility Accidents[a] (Cont.)	
Consequences (per accident)	
Chemical exposure – public	No adverse effects
Chemical exposure – Noninvolved workers[e]	
Adverse effects	70
Irreversible adverse effects	3
Fatalities	0
Radiation exposure – public	
Dose to MEI	3 mrem
Risk of LCF	1 in 1 million
Total dose to population	0.4 person-rem
Total LCFs	0
Radiation exposure – Noninvolved workers[e]	
Dose to MEI	77 mrem
Risk of LCF	3 in 100,000
Total dose to workers	2.2 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Low Frequency-High Consequence Cylinder Accidents[f]	
Accident[d]	Vehicle-induced fire, 3 full cylinders (high for adverse effects); corroded cylinder spill, wet conditions (high for irreversible adverse effects)
Release	Uranium, HF
Estimated frequency	~ 1 in 100,000 years
Accident probability (1999–2039)	~ 1 chance in 2,500
Consequences (per accident)	
Chemical exposure – public	
Adverse effects	1,900
Irreversible adverse effects	1
Fatalities	0
Chemical exposure – noninvolved workers[e]	
Adverse effects	1,000
Irreversible adverse effects	300
Fatalities	3
Radiation exposure – public	
Dose to MEI	15 mrem
Risk of LCF	7 in 1 million
Total dose to population	1 person-rem
Total LCFs	0

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
Human Health and Safety — Facility Accidents[a] (Cont.)	
Radiation exposure – noninvolved workers[e]	
Dose to MEI	20 mrem
Risk of LCF	8 in 1 million
Total dose to workers	16 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Accidents Involving Releases of Chemicals or Radiation: Low Frequency-High Consequence Accidents at All Facilities[f]	
Chemical accident[d]	HF or NH_3 tank rupture
Release	HF, NH_3
Accident location	Conversion site
Estimated frequency	< 1 in 1 million years
Accident probability (1999–2039)	1 chance in 50,000 (over 20 years)
Consequences (per accident)	
Chemical exposure – public	
Adverse effects	41,000
Irreversible adverse effects	1,700
Fatalities	30
Chemical exposure – noninvolved workers[e]	
Adverse effects	1,100
Irreversible adverse effects	440
Fatalities	4
Accident risk (consequence times probability)	
General public	0 fatalities
Noninvolved workers	0 fatalities
Radiological accident	Earthquake damage to storage building at conversion site
Release	Uranium (UO_2)
Accident location	Conversion site
Estimated frequency	1 in 100,000 years
Accident probability (1999–2039)	1 chance in 5,000 (over 20 years)

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
Human Health and Safety — Facility Accidents[a] (Cont.)	
Consequences (per accident)	
Radiation exposure – public	
Dose to MEI	68 mrem
Risk of LCF	3 in 100,000
Total dose to population	5 person-rem
Total LCFs	0
Radiation exposure – noninvolved workers[e]	
Dose to MEI	2,300 mrem
Risk of LCF	9 in 10,000
Total dose to workers	210 person-rem
Total LCFs	0
Accident risk (consequence times probability)	
General public	0 LCFs
Noninvolved workers	0 LCFs
Human Health and Safety — Transportation[a]	
Major Materials Assumed to Be Transported between Sites	UF_6 cylinders Uranium oxide Uranium metal HF (if produced) CaF_2 (if produced) NH_3 MgF_2 LLW/LLMW Casks
Normal Operations	
Fatalities from exposure to vehicle exhaust and external radiation	0 to 1
Maximum radiation exposure to a person along a route (MEI)	Less than 0.1 mrem
Traffic Accident Fatalities (1999–2039) (physical hazards, unrelated to cargo)	
Maximum use of trucks	4 fatalities
Maximum use of rail	1 fatality

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
Human Health and Safety — Transportation[a] (Cont.)	
Traffic Accidents Involving Releases of Radiation or Chemicals	
Low Frequeny-High Consequence Cylinder Accidents	
Accident	Urban rail accident involving 4 cylinders
Release	Uranium, HF
Accident probability (1999–2039)	1 chance in 10,000
Consequences (per accident)	
Chemical exposure –All workers and members of general public	
Irreversible adverse effects	4
Fatalities	0
Radiation exposure – All workers and members of general public	
Total LCFs	60
Accident Risk (consequence times probability)	
Workers and general public	0 fatalities
Low Frequency-High Consequence Accidents with All Other Materials	
Accident	Urban rail accident involving anhydrous HF
Release	Anhydrous HF
Accident probability (1999–2039)	1 chance in 30,000
Consequences (per accident)	
Chemical exposure – workers and members of general public	
Irreversible adverse effects	30,000
Fatalities	300
Accident risk (consequence times probability)	
Irreversible adverse effects	1
Fatalities	0

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
Air Quality	
Current Storage Sites	
Pollutant emissions during construction	Maximum 24-hour PM_{10} concentration up to 95% of standard; other criteria pollutants well within standards
Pollutant emissions during operations	Maximum 24-hour HF concentration up to 93% of standard at K-25; HF concentrations well within standards at other sites; criteria pollutants well within standards at all sites
Other Facilities[g]	
Pollutant emissions during construction and operations	Maximum 24-hour PM_{10} concentration up to 90% of standard; other pollutant emissions well within standards (all less than 30% of standards)
Water and Soil [h]	
Current Storage Sites	
Surface water, groundwater, and soil quality	Uranium concentrations would remain within guideline levels
Other parameters[i]	No change
Other Facilities[g]	
Surface water, groundwater, and soil quality	Site-dependent; contaminant concentrations could be kept within guideline levels
Other parameters[i]	Site-dependent; none to moderate impacts
Socioeconomics[j]	
Current Storage Sites	
Continued storage	**Jobs:** 30 peak year, construction; 120 per year over 20 years operations **Income:** $1.4 million peak year, construction; $6 million per year over 20 years operations

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
	Socioeconomics[j] (Cont.)
Cylinder preparation	**Jobs:** 0–580 peak year, preoperations; 300–490 per year over 20 years operations **Income:** \$0–26 million peak year, preoperations; \$19–25 million per year over 20 years operations
Other Facilities[g]	
Conversion	**Jobs:** 710–1,100 peak year, construction; 520–770 per year over 20 years operations **Income:** \$29–47 million peak year, construction; \$31–44 million per year over 20 years operations
Manufacturing	**Jobs:** 300 peak year, construction; 540 per year over 20 years operations **Income:** \$14 million peak year, construction; \$38 million per year over 20 years operations
	Ecology
Current Storage Sites	
Habitat loss[k]	Up to 28 acres; negligible to potential moderate impacts
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	None to negligible impacts
Other Facilities[g]	
Habitat loss[k]	**Conversion:** Up to 29 acres at a single site; total of 56 acres; potential moderate impacts to vegetation and wildlife **Manufacturing:** Up to 84 acres at a single site; total of 170 acres; potential moderate to large impacts to vegetation and wildlife

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
	Ecology (Cont.)
Concentrations of chemical or radioactive materials	Below harmful levels; potential site-specific effects from facility or transportation accidents
Wetlands and threatened or endangered species	Site-dependent; avoid or mitigate
	Waste Management
Current Storage Sites	**LLW:** no impacts **LLMW:** potential moderate impacts with respect to current waste generation at Paducah (> 20%); negligible impacts with respect to Portsmouth, K-25, or nationwide waste generation
Other Facilities[g]	
Conversion	Potential moderate impacts to current nationwide LLW generation for CaF_2 (if produced and not used) and MgF_2 as LLW (if required); potential moderate impact to site waste generation for CaF_2 and MgF_2 as nonhazardous solid waste
Manufacturing	Negligible impacts with respect to current regional or nationwide waste generation
	Resource Requirements[l]
All Sites	No effects on local, regional, or national availability of materials are expected
	Land Use
Current Storage Sites	Up to 28 acres; less than 1% of available land; negligible impacts
Other Facilities[g]	
Conversion	Up to 29 acres at a single site; total of up to 56 acres; potential moderate impacts
Manufacturing	Up to 84 acres at a single site; total of 170 acres; potential moderate impacts

TABLE K.10 (Cont.)

Environmental Consequence	Case 7: 50% Use as Uranium Oxide; 50% Use as Metal
Cultural Resources	
Current Storage Sites	Impacts unlikely
Other Facilities[g]	Impacts dependent on location; avoid and mitigate
Environmental Justice	
All Sites	No disproportionately high and adverse impacts to minority or low-income populations in the general public during normal operations or from accidents; severe transportation accidents are unlikely and occur randomly along routes; therefore, high and adverse impacts to minority or low-income populations are unlikely

[a] For purposes of comparison, estimates of human health effects (e.g., LCFs) have been rounded to the nearest whole number. Accident probabilities are the estimated frequencies multiplied by the number of years of operation.

[b] Chemical exposures for involved workers during normal operations would depend in part on of facility designs. The workplace environment would be monitored to ensure that airborne chemical concentrations were below applicable exposure limits.

[c] Accidents with probabilities of occurrence greater than 0.01 per year.

[d] On the basis of calculations performed for the PEIS, the accidents that are listed in this table have been found to have the highest consequences of all the accidents analyzed for the given frequency range. In general, accidents that have lower probabilities have higher consequences.

[e] In addition to noninvolved worker impacts, chemical and radiological exposures for involved workers (workers within 100 m of a release) under accident conditions would depend in part on facility designs and other factors (see Section 4.3.2.1).

[f] Accidents with probabilities of occurrence from 0.0001 per year to less than 0.000001 per year.

[g] Other facilities are facilities for conversion and manufacturing.

[h] The guideline concentration used for comparison with estimated surface water and groundwater uranium concentrations is the proposed U.S. Environmental Protection Agency (EPA) maximum contaminant level of 20 µg/L (EPA 1996); this value is an applicable standard for water “at the tap” of the user and is not a directly applicable standard for surface water or groundwater (no such standard exists). The guideline concentration used for comparison with estimated soil uranium concentrations is a health-based guideline value for residential settings of 230 µg/g.

[i] Other parameters evaluated include changes in runoff, floodplain encroachment, groundwater recharge, depth to groundwater, direction of groundwater flow, soil permeability, and erosion potential.

Footnotes continue on next page

TABLE K.10 (Cont.)

Foonotes (Cont.)

[j] For construction, direct jobs and direct income are reported for peak construction year. For operations, direct jobs and income are presented as annual averages, except for continued storage, which is reported for the peak year of operations.

[k] Habitat losses and land-use acreages given as maximum for a single site or facility. Conversion facilities would also need to establish protective action distances encompassing 960 acres around the facility.

[l] Resources evaluated include construction materials (e.g., concrete, steel, special coatings), fuel, electricity, process chemicals, and containers (e.g., drums and cylinders).

Notation: CaF_2 = calcium fluoride; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; LLMW = low-level mixed waste; MEI = maximally exposed individual; MgF_2 = magnesium fluoride; NH_3 = ammonia; PM_{10} = particulate matter with a mean diameter of 10 µm or less; UF_6 = uranium hexafluoride.

K.8 REFERENCES FOR APPENDIX K

EPA: see U.S. Environmental Protection Agency.

Lawrence Livermore National Laboratory, 1996, unpublished data, preliminary cost estimate reports and details, Livermore, Calif., Feb.–Sept.

Lawrence Livermore National Laboratory, 1997a, *Depleted Uranium Hexafluoride Management Program; the Engineering Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride*, UCRL-AR-124080, Volumes I and II, prepared by Lawrence Livermore National Laboratory, Science Applications International Corporation, Bechtel, and Lockheed Martin Energy Systems for U.S. Department of Energy.

Lawrence Livermore National Laboratory, 1997b, *Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride*, UCRL-AR-127650, prepared by Lawrence Livermore National Laboratory, Livermore, Calif., for U.S. Department of Energy, May.

LLNL: see Lawrence Livermore National Laboratory.

Tomasko, D., 1997, *Water and Soil Impact Analyses in Support of the Depleted Uranium Hexafluoride Programmatic Environmental Impact Statement*, attachment to memorandum from D. Tomasko (Argonne National Laboratory, Argonne, Ill.) to H.I. Avci (Argonne National Laboratory, Argonne, Ill.), May 21.

U.S. Environmental Protection Agency, 1996, *Drinking Water Regulations and Health Advisories*, EPA 882-B-96-002, Office of Water, Washington, D.C., Oct., pp. 1-11.